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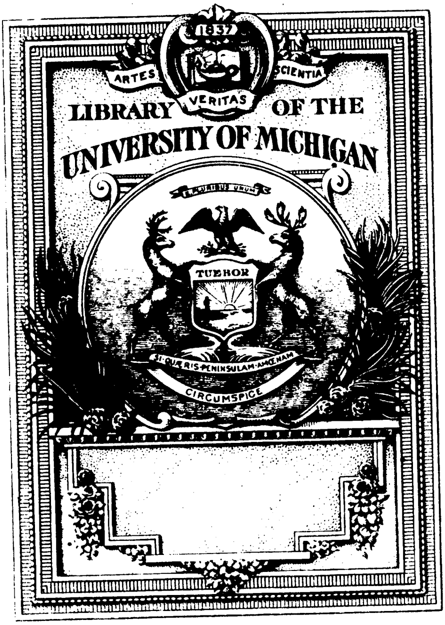

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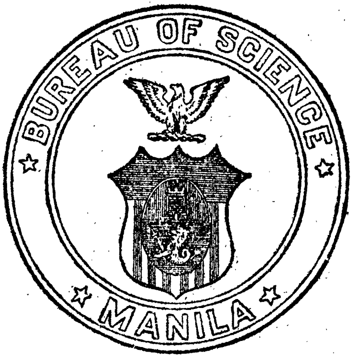

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 24 JANUARY, 1924 No. 1

EPIDEMIC ENCEPHALITIS (ENCEPHALITIS LETHARGICA)

REPORT OF AN OUTBREAK OCCURRING IN THE PHILIPPINE ISLANDS WITH NOTES ON THE PATHOLOGICAL FINDINGS

By LAWRENCE WELD SMITH

Of the Department of Pathology and Bacteriology, College of Medicine and Surgery, University of the Philippines, and the Pathological Laboratory, Philippine General Hospital

FIVE PLATES AND ONE TEXT FIGURE

INTRODUCTION

Epidemic encephalitis (encephalitis lethargica) has occupied such a prominent place in medical literature during the past five years, since the original report by von Economo (23) of an epidemic in Vienna, presenting the syndrome now associated with that disease, that any detailed historical consideration at this time would be redundant. In a general way, as Flexner (10) pointed out, the disease spread from Austria over continental Europe during the winter of 1917 and 1918 and reached America on its eastern shores shortly after. From there it passed rapidly across the United States during that year and then gradually disappeared in pandemic form, only sporadic and scattered cases being reported here and there. Almost coincidentally with the Viennese outbreak, Cleland and others (6) reported a somewhat similar disease in Australia which was termed "X" disease or acute encephalomyelitis. In the Philippine Islands a few atypical cases were noted during 1918 and 1919, three of which were corroborated by autopsy and reported by de

Leon.(8) At no time did the conditions here assume the proportions of an epidemic, even in Manila.

The other feature of general interest associated with the development of this pandemic has been its possible relationship to influenza, as it closely followed in the wake of that disease. Indeed, the literature teems with theoretical expositions of the unquestionable etiological basis of influenza; but several investigators feel that this relationship is merely one of coincidence and not of cause and effect. Personally, I am of this group, and I feel my stand has been somewhat strengthened by the recent outbreak of encephalitis in Manila, which occurred without any apparent preceding influenza epidemic.

In this connection one's opinion must be largely formed by impression and statistics, both of which notoriously may be in error. Unfortunately, statistics for the Philippine Islands as a whole are incomplete, and I am forced unwillingly to refer to those of the city of Manila as representative. Figures are available in the annual reports of the Philippine Health Service which conclusively show the relative annual incidence of influenza, as this disease has been reportable for a number of years. In Manila, a city of approximately 300,000 people, there are ordinarily reported less than 300 cases of influenza annually. Such has been the case for the past seven years, with the exception of 1918, when the number reached nearly 40,000. The final figures for 1922 are not yet complete, but a preliminary examination indicates no noteworthy increase in the incidence of influenza. Allowing for the natural errors of diagnosis in a respiratory-tract disease presenting so variable a clinical picture, we should probably agree that these figures at least represent its relative incidence.

The chief points to be noted are the facts that since the epidemic of influenza in 1918 and 1919 the disease has been present only in sporadic form and that from then to the present no epidemic of encephalitis has been noted in either of two of the largest hospitals, the Philippine General Hospital and the San Lazaro Public Health Service Hospital.

Then suddenly, early in November, 1922, without any apparent coincidental increase of influenza, and occurring usually in individuals with no previous history of influenza, either recently or in 1918, there developed an epidemic of a nervous disorder related very closely in appearance to the so-called myoclonic and choreiform types of epidemic encephalitis. This progressed steadily, reaching its peak about the middle of January, 1923, and has tended to decrease since that time. It is too early to obtain the final statistics from the records of the Philippine Health Service, and my statements are based largely on the incidence of the cases in the two aforementioned hospitals where I personally had an opportunity of checking the clinical diagnosis fairly regularly at autopsy, either by performing the necropsy personally or by studying the material histologically.

The more complete epidemiological studies will probably be presented later. However, a few general facts are not out of place here. The disease as it occurred in these hospitals was a disease chiefly of adult males. The spread of the infection has been as mysterious as that of anterior poliomyelitis or influenza itself. The first case seen in Manila was in a sailor on one of the interisland boats, in November, 1922. From that time it spread very widely, apparently without direct contact, as this patient was removed from the boat to a hospital where he died within a few days. The cases were found in all parts of the city—in only one instance two were in the same family or house—usually scattered here and there through the various sections of the town. It affected the different classes of society about proportionally, but the individuals were usually males from 18 to 30 years of age. Isolated cases from as far as 80 kilometers away were brought to the hospital, with no history of exposure that could be ascertained.

Mortality is high; in the group of cases from the Philippine General Hospital there were thirteen deaths in which autopsy confirmed the diagnosis, and there were three probable cases in which autopsy was refused. Several other cases were originally tentatively included clinically, but autopsy revealed tuberculous meningitis, cerebral hæmorrhage, typhoid meningismus, etc., as the case might be. Recovery in a case presenting characteristic symptoms usually was considered positive evidence, as eliminating tuberculous meningitis as the chief single source of diagnostic errors; of the hospital cases which we can consider fairly definitely clinically as epidemic encephalitis there was a total of 33 with 16 deaths, a mortality of 48.4 per cent.

In addition to these sixteen cases I was privileged in performing three autopsies on cases dying in other hospitals, the bodies of which were transferred to the City Morgue for post-mortem examination. I also had the opportunity of witnessing the necropsy of a case from the Sternberg General Hospital, United States Army, besides seeing the histological preparations from two other cases from that institution. Furthermore, I received the coöperation of several physicians and was thus enabled to see several other cases clinically and secure laboratory data upon them. Through their kindness, likewise, I have been able to secure the data from several Manila and provincial hospitals concerning the incidence and mortality in those places. So far as I am aware, only two towns of any considerable size outside of Luzon have suffered from the epidemic; these are Zamboanga and Cebu. The latter had only two cases clinically, both of which recovered. These occurred at the same time that the epidemic appeared in Manila, although Cebu is nearly 640 kilometers farther south and completely isolated from there except by boat.

In Zamboanga, on the other hand, which is about 960 kilometers south of Manila, the disease did not appear until March, some time after the peak of the Manila outbreak had been reached. There were thirteen cases in the hospital, in general of a somewhat milder form. I had the good fortune to see all of these cases but one, which had died and on which an autopsy had been performed by Dr. C. Manalang. I understand from a communication from him that one more of the cases has since terminated fatally. A discussion of the outbreak there is being published by Doctors Manalang and Rodriguez, of the Philippine Health Service. (17)

Table 1 shows the incidence and the mortality as completely as I have been able to secure the information to date. It is obviously very incomplete from the epidemiological standpoint, but will I think tend to show the epidemic character of the disease and its apparent independence of influenza. The epidemiological and clinical aspects of the epidemic will be reported by other members of the hospital staff and health service, so I shall confine my attention in so far as possible to the more purely laboratory side.

Text figure 1 is an attempt to show, with the data available at the present writing, the morbidity and the mortality for Manila, month by month. I am indebted to Dr. Vicente de Jesus, director of the Bureau of Health, for permission to use these figures. The final statistics will appear in the annual health report, but these figures give us a very satisfactory picture of the relative course of the epidemic.

It is interesting perhaps also to analyze briefly some of the other statistical information we have at hand. In the thirty-six cases from the Philippine General Hospital the average duration for all the cases, from the time of onset of the disease as ac-

TABLE 1.—*Morbidity and mortality of epidemic encephalitis.*

Hospital.	Cases.			Age.			Previous history of influenza.	Deaths.			Mortality.
	Male.	Female.	Total.	Youngest.	Oldest.	Average.		Male.	Female.	Total.	
				Years.	*Years.*	*Years.*					*Per cent.*
Philippine General	24	9	33	3	41		(?)	15	1	16	48.4
San Lazaro											
Chinese General	2	1	3	19	49	34	0	1	1	2	66.6
San Juan de Dios	7	0	7	16	40		0	2	0	2	28.5
Saint Paul's	3	1	4	21	49	32	0	0	1	1	25
Mary J. Johnston	0	1	1			26	0	0	0	0	
Mary Chiles											
Bilibid Prison	1	0	1			23	0	1		1	100
Sternberg General	6	0	6	27	42	34.2	0	5	0	5	83.3
Hospital Español	0	0	0					0	0	0	
Average											50.2
Zamboanga General			13							2	15.5
Southern Islands, Cebu			2							0	

curately as could be ascertained by the history to the time of discharge, is given in Table 2. The cases are further grouped to show the duration of the fatal ones in contrast to those that recovered and in Table 3 will be found similar information from some of the other hospitals. By giving each of these groups a relative value, dependent on the number of cases, a general average has also been obtained for the fatal cases.

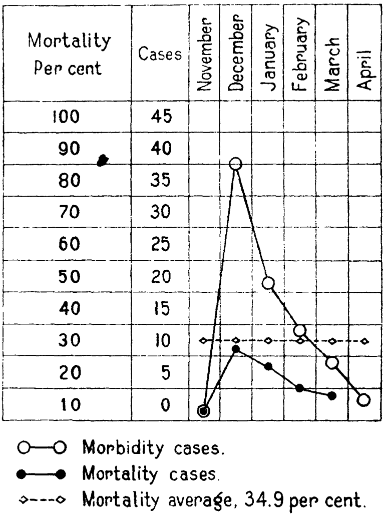

FIG. 1. Morbidity and mortality of epidemic encephalitis in Manila for three months in 1922 and three months in 1923.

SCOPE

This work is based chiefly on the histological examination of material obtained at autopsy from the fatal cases. In addition it includes observations on the clinico-pathological laboratory findings of the blood, urine, and spinal fluid of many of the cases that recovered.

These body fluids yielded very little information, either from the point of view of diagnosis or from that of prognosis, except in a negative way. The urine is probably the least valuable in

TABLE 2.—*Showing the age incidence and the duration of the disease; complete data on thirty-three cases.*

Cases.	Average age.	Average duration.
	Years.	*Days.*
Males and females	25.8	40
Males and females, fatal cases	24.7	16.5
Males and females, recovered cases	21	63.6
Males, 24 cases	25	37
Males, fatal, 15 cases	25	14.5
Males recovered, 9 cases	25.7	75.6
Females, 9 cases	16.3	51
Females, fatal, 1 case	20	45
Females recovered, 8 cases	15.8	51.7
Youngest case, female	2.3	77
Oldest case, male	53	(?)
Shortest duration case, male	25	5
Longest duration case, male	19	142

TABLE 3.—*Showing relative duration of disease in fifty-four cases on which data have been supplied. Averages are obtained by crediting the figures on their percentage of the total number of cases.*

Hospital.	Cases.	Average duration in days.					
		All cases.		Recovered.		Fatal.	
		Actual.	Value.	Actual.	Value.	Actual.	Value.
			P. ct.		*P. ct.*		*P. ct.*
Philippine General	33	40	29.2	63.6	53.8	16.5	10.4
San Juan de Dios	7	40.6	6.8	------	------	35	4.5
Sternberg General	6	------	------	33	24	15.6	1.7
Saint Paul's	4	40	3.5	------	------	25	1.8
Chinese General	3	------	------	------	------	16	0.8
Mary J. Johnston	1	55	1.3	------	------	------	------
Total	54	------	40.8	------	77.8	------	19.2

this connection. Table 4 gives the results of urine examination in the cases from the Philippine General Hospital in which urinalysis was done, diagnosed as encephalitis. In some cases several examinations were made, and in preparing this table I have endeavored to utilize the most pathological specimen to emphasize the very slight importance which can be attached to such examination in this disease.

It will be noted that very few cases show even the slightest possible trace of albumin. This is not surprising in view of the fact that the temperature rarely reaches 39° C. (occasionally as a terminal rise), and thus febrile albuminuria, which is a feature of many disease processes, is lacking. The microscopic examination likewise is negative from the point of view of pathognomic evidence, the rare cast or pus cell being parallel with the albumin and usually evidence of previous kidney disease.

In the same way the blood findings are of very little significance. In Table 5 I have attempted to analyze the blood picture. It will be seen that the white count varies considerably, ranging from about 4,000 to 30,000.(14) This seems to be dependent upon some factor other than the nonsuppurative central nervous infection alone, for in entirely uncomplicated cases we note at most only a very slight rise. In cases where definitely visible hæmorrhagic areas occur in the nervous tissues the tendency is, possibly, for the white count to rise slightly, dependent presumably on the toxic absorption of the necrotic tissue. This is not necessarily of prognostic value, as many of the fatal cases

TABLE 4.—*Showing results of urine examination of Philippine General Hospital cases*[a] *diagnosed as encephalitis.*

Serial No.	Hospital No.	Sex.	Age.	Color.	Transparency.	Reaction.	Albumin.	Sugar.	Sediment.
			Yrs.						
1	103333	M.	22	Pale	Clear	Acid	Negative	Negative	Negative.
2	103408	M.	19	Amber	do	do	do	do	Do.
3	103610	M.	41	do	Turbid	do	Slight trace	do	Occasional cast.
4	103660	M.	27	Straw	Clear	do	Negative	do	Negative.
5	103800	M.	17	Pale	Cloudy	do	Very slight trace	do	Do.
6	104161	M.	24	Amber	do	Alkaline	Negative	do	Do.
7	104312	M.	21	do	Clear	Acid	Slight trace	do	A few granular casts.
8	104540	M.	19	do	Cloudy	do	Very slight trace	do	Do.
9	104686	M.	37	do	Clear	do	Negative	do	Negative.
10	106087	F.	20	Pale	do	do	do	do	Do.
11	106221	M.	41	Amber	Cloudy	do	do	do	Do.
12	106277	F.	23	Pale	Clear	do	do	do	Do.
13	107439	M.	28	Dark	do	Alkaline	Very slight trace	do	Do.

[a] The records of the other cases are either incomplete or lacking. The albumin is only occasional and apparently dependent on fever or previous kidney disease.

show no reaction of the bone marrow whatsoever, as evidenced by the examination of the peripheral blood.

The differential count likewise gives us little information, except that there is some relative increase in the polynuclear percentage, which is of some significance, for it must be remembered that the normal percentage value of the lymphocytes among Filipinos is high, in contrast to the American or the European. We should not expect the red cells and hæmoglobin to show any change, and in the cases where such examinations were made, nothing of significance was noted. Similarly, the coagulation and bleeding times showed no pathological variation in several cases examined.

TABLE 5.—*Blood findings in encephalitis.*

Serial No.	Hospital No.	Sex.	Age.	Red cells per cubic millimeter.	White cells per cubic millimeter.	Hæmoglobin.	Differential count.			
							Neutrophiles.	Lymphocytes.	Eosinophiles.	All others.
			Yrs.			*P. ct.*				
1	102946	F.	12	------------	15,600	-------	74	25	0	1
2	103333	M.	22	------------	16,000	-------	59	35	2	4
3	103341	F.	20	------------	10,000	-------	87	11	0	2
4	103361	M.	22	------------	8,400	-------	58	35	4	3
5	103408	M.	19	------------	14,800	-------	81	12	6	1
6	103610	M.	41	------------	10,200	-------	85	15	0	0
7	103660	M.	27	------------	9,000	-------	82	18	0	0
8	104019	F.	13	------------	5,200	-------	90	10	0	0
9	104020	M.	20	------------	11,500	-------	71	27	1	1
10	104035	M.	22	------------	11,600	-------	76	21	2	1
11	104156	M.	31	------------	20,800	-------	92	8	0	0
12	104161	M.	24	------------	21,000	-------	75	21	1	3
13	104299	M.	15	------------	10,200	-------	75	22	1	2
14	104312	M.	21	4,000,000	10,200	75	79	18	0	3
15	104458	M.	41	------------	11,200	-------	80	18	0	2
16	104540	M.	19	------------	27,200	-------	84	12	1	3
17	104635	F.	15	------------	10,000	-------	89	9	0	2
18	104686	M.	37	------------	8,600	-------	85	12	2	1
19	104764	M.	18	3,190,000	7,800	70	76	22	1	1
20	104850	M.	25	------------	9,800	-------	86	11	1	2
21	104958	F.	13	------------	7,200	-------	70	30	0	0
22	105905	M.	3	------------	16,400	-------	88	11	1	0
23	106087	F.	20	------------	8,000	-------	83	17	0	0
24	106221	M.	41	3,900,000	5,000	75	87	12	0	1
25	106277	F.	23	4,190,000	10,000	80	78	21	1	0
26	106565	F.	2	------------	9,000	-------	66	34	0	0
27	106766	F.	31	3,350,000	7,800	65	51	43	5	1
28	107439	M.	28	------------	10,000	-------	86	10	0	4
Average	------	------		------------	11,553	-------	78.4	19.3	1.0	1.3

The findings of the spinal fluid are of the most value diagnostically, from the laboratory point of view. However, they are of more interest from the negative than from the positive viewpoint. As will be noted by an examination of Table 6, two rather constant findings are recorded. One of these is a noticeable increase in the reduction of Fehling's solution, and the other is a very low cell count, usually under 20 per cubic millimeter. The spinal fluid in general may be said to show slightly increased pressure (in about 70 per cent of the cases where it was recorded), to have a nearly normal cell count, rarely to contain demonstrable globulin, and to possess an in-

TABLE 6.—*Spinal-fluid examinations.*

[0, no reduction; —, normal reduction; +, appreciable increase in reduction; ++, marked increased reduction.]

Serial No.	Hospital No.	Sex.	Age.	Protein.	Sugar.	Cell count per cubic millimeter.	Differential count.		Clinical outcome.
							Polynuclears.	Lymphocytes.	
			Yrs.				*P. ct.*	*P. ct.*	
1	102946	F.	12	—	—	6	—	—	Improved.
2	103333	M.	22	—	—	20	—	(a)	Do.
3	103341	F.	20	Very slight trace	—	20	—	—	Died.
4	103361	M.	22	do.	+	5	—	(a)	Improved.
5	103408	M.	19	Slight trace	++	7	------	(a)	Recovered.
6	103660	M.	27	Trace	+	7	—	(a)	Do.
7	103800	M.	17	Negative	+	8	—	—	Died.
8	104019	F.	13	Slight trace	0	5	—	(a)	Recovered.
9	104035	M.	22	—	+	10	—	(a)	Improved.
10	104156	M.	31	Negative	++	5	—	—	Died.
11	104161	M.	24	Very slight trace	++	8	20	80	Do.
12	104299	M.	15	—	0	7	—	—	Recovered.
13	104312	M.	21	Trace	++	30	—	(a)	Died.
14	104540	M.	19	Negative	+	7	—	—	Do.
15	104635	F.	15	—	—	3	—	(a)	Recovered.
16	104686	M.	37	Negative	Negative.	2	—	—	Died.
17	104764	M.	18	—	+	32	—	—	Do.
18	104850	M.	25	Negative	+	2	—	—	Do.
19	104958	F.	13	Slight trace	++	6	—	(a)	Improved.
20	105844	M.	15	Trace	++	10	—	(a)	Died.
21	105905	M.	3	Negative	+	10	—	—	Do.
22	106087	F.	20	do.	+	3	—	—	Improved.
23	106221	M.	41	Slight trace	++	5	—	—	Recovered.
24	106277	F.	23	Very slight trace	+	7	5	95	Do.
25	106565	F.	2	Slight trace	++	20	10	90	Do.
26	106766	F.	31	Very slight trace	+	2	—	—	Improved.
27	107439	M.	28	Slight trace	++	40	—	—	Died.
Average						10.6			

[a] Predominance.

creased sugar content as evidenced by its ability to precipitate the copper salts. These findings are in accord with those of other investigators, among whom may be cited Ayer,(3) Hodges,(12) and Thalheimer.(22)

PATHOLOGY

The pathology of the disease is well defined. It has been so thoroughly described by numerous workers (8, 16, 11, 13, 15, 20, 2, 7, 18) that I shall endeavor to condense the findings in these cases as much as possible to a simple tabular form, and merely give a composite description of the essential changes. As has been often emphasized, the term encephalitis lethargica is an unfortunate one—a symptomatic descriptive phrase, which applies either to a relatively small number of the cases or simply to a single phase of the disease. From the pathological standpoint a more-inclusive anatomical name such as the occasionally used "encephalomyelitis" or "polioencephalomyeloneuritis" would be more appropriate, (19, 5, 1) as the lesions are by no means confined to the encephalon. Indeed, in this group of cases, the floor of the fourth ventricle, the medulla, the cervical cord, and spinal ganglia showed much more marked lesions than the motor cortex or other portions of the cerebrum or cerebellum.

A routine method for the examination of these bodies was adopted in an effort to standardize the data. This consisted in the preliminary opening of the spinal column and skull and the sterile removal of the spinal cord in its entirety for animal inoculation and bacteriologic studies. Following the utilization of such material as was needed, the rest of the cord and the brain were sectioned and blocks cut from comparative portions. In general, sections were removed in order from the motor cortices, the sensory cortices, the corpora striata, the cerebellar peduncles, through several portions of the brain stem, from the cervical, thoracic, and lumbar levels of the spinal cord and, in a few cases, from spinal ganglia in the thoracic region. They were cut from 2 to 4 millimeters in thickness and fixed in (*a*) Zenker's fluid, (*b*) 10 per cent formalin, and (*c*) Carnoy's fluid for the demonstration of nerve fiber and cell degeneration, according to the technic of Maj. George R. Callender, of the United States Army Medical Research Board in Tropical Medicine.

Following the removal of the central nervous system a routine examination of the other viscera was made, and sections from all the organs preserved for microscopic study. The gross findings were nearly constant and, while the changes grossly were only slight (in view of the clinical history), very little difficulty was had in making a tentative anatomical diagnosis. The following is the report of an autopsy protocol which has been chosen almost at random, so closely do the findings in general coincide:

Autopsy 9527.—Body is that of a well-developed, well-nourished, female Filipino, 20 years old, measuring 145 centimeters in length and weighing 30.9 kilograms. Rigor mortis is marked, particularly in the abdominal muscles. There is slight post-mortem lividity in the dependent portions. There is no œdema. The eyes are not shrunken, the scleræ are clear, and the pupils are regular and equal. The mouth is in fair condition. Chest is symmetrical. Abdomen is sunken and scaphoid. External genitalia are negative. Superficial lymph nodes show enlargement. The skin is essentially negative, except for a small scar in the right axillary line anteriorly.

The abdominal wall contains 2 or 3 centimeters of a deep yellowish fat; the musculature is normal in color and consistency. Peritoneal cavity contains neither free fluid nor adhesions. The omentum is negative. The appendix measures 5 centimeters in length, is retrocecal in position, and normal in appearance. Mesenteric lymph nodes show no enlargement. The diaphragm reaches the fourth interspace on the right and the fifth rib on the left. Mediastinum is negative, although there is an atrophic thymic raise present.

Pleural cavities contain no free fluid and no adhesions. Pericardial cavity is negative.

The heart weighs 137 grams. The myocardium is deep brownish red and shows marked congestion. The coronary vessels likewise are congested and prominent. The endocardium is smooth and glistening. There are no valvular defects. Valve measurements: Tricuspid, 10.8 centimeters; pulmonary, 6.8; mitral, 8.5; aortic, 6.2; left ventricle, 1.3; right ventricle, 0.3.

The lungs are entirely negative except for slight hyperplastic congestion in the posterior portion, particularly at the base. The hilus lymph nodes are negative.

The spleen weighs 50 grams. It is small. Its capsule is slightly wrinkled. On section the follicles are barely visible as minute grayish white pin-point areas. The pulp is moderately congested and there is a relative increase of connective tissue in the trabeculæ, giving a firm consistency to the organ. The appearance is one of simple atrophy.

The liver weighs 610 grams. Its capsule is smooth and glistening. It is pale and somewhat mottled in appearance. This is distinctly small and again suggests an atrophic condition. On section moderate fatty change of the liver parenchyma is noted. No actual central necrosis is seen. There is no increase of connective tissue visible and there is no bile stasis. Gall bladder and ducts are negative.

The pancreas weighs 63 grams and shows no gross change. Alimentary tract: Stomach is small and atrophic. Its mucosa is negative. The small intestine measures 595 centimeters in length and is negative except for the presence of an ascaris worm. Lymphoid tissue and ileum show no hypertrophy, and nothing to suggest typhoid infection. The large intestine measures 175 centimeters and is entirely negative.

Adrenals: The right weighs 10 grams and the left 12. Except for relative hypertrophy they show no gross change.

Kidneys: The right weighs 80 grams and the left 90. They are extremely congested. Their capsules strip readily, leaving a deep red congested smooth surface. On section the cortical medullary demarcation is sharp. The calyces and pelves appear negative. Ureters and bladder are normal.

Genitalia: The uterus is apparently in the early congested period of menstrual cycle and the ovaries likewise show marked congestion. There is a small corpus luteum measuring 4 millimeters in diameter in the tip of the left ovary.

The organs of the neck are negative.

The brain is removed and weighs 1,162 grams. There are moderate œdema and congestion of the meninges and of the brain tissue itself. Section through the corpus striatum shows very distinct focal areas of degeneration with barely visible petechial hæmorrhages. There are less-marked degenerative changes visible in the medulla, pons, and in the region of the dentate nucleus of the cerebellum. The vessels in these areas are intensely congested, and a few places suggest capillary hæmorrhages. The spinal cord is removed and marked congestion and œdema again are noted. This is most marked in the gray matter of the cord in both the posterior and anterior horns. The most-marked lesions in the upper portion of the cord show fecal areas of degeneration with petechial hæmorrhages.

The aorta shows no atheromatous changes.

Duration of illness: One month and 15 days.

Clinical diagnosis: Encephalitis lethargica, myoclonic type.

Anatomic diagnosis: Encephalo-myelitis, acute; petechial hæmorrhages of corpus striatum, cerebellar dentate nucleus and both posterior and anterior horns of spinal cord; œdema and congestion of brain and meninges; generalized visceral congestion; fatty infiltration of liver.

Necropsy held thirty hours after death.

The autopsy findings, as observed grossly, are relatively insignificant. There is in general a diffuse venous congestion of the viscera, with a tendency for cardiac dilatation suggestive of a terminal toxæmia with cardiac failure. The lungs show no pathognomonic changes, but are apt to be heavy and boggy with capillary distention and œdema. The spleen varies so greatly as to make the changes noted of little significance. It is often somewhat larger than normal with prominence of the follicles, but the changes are not as constant even as those found in anterior poliomyelitis. The liver presents usually more or less congestion of the sinuses, at times increasing the size of the organ noticeably and oozing fluid freely on section. The other features are much less regular; namely, occasional fatty changes and slight central necrosis, which can perhaps be attributed to the toxæmia of the disease. The kidneys also are very liable to be congested, but without showing definite kidney damage.

The only lesions that are in the least characteristic are those of the central nervous system; and even here, in many of the cases, they cannot be recognized without microscopic aid. Characteristically, we find a marked œdema not only of the arachnoid spaces but of the brain and spinal-cord substance itself. This gives a semitranslucent appearance to the gray matter of the brain and cord. It is particularly prominent on sectioning the cord which immediately bulges over the cut dura.

Aside from the œdema and congestion, there may or may not be visible punctate capillary hæmorrhages. These are usually found in the region of the caudate and lenticular nuclei, of the substantia nigra, of the floor of the fourth ventricle, and of the cervical cord, and are extremely minute in character.

Microscopically, likewise, the lesions are singularly uniform. In the cerebrum itself, in the region of both the motor and sensory cortices, there are seldom any demonstrable lesions beyond capillary dilatation and œdema. Occasionally a few red cells can be seen which apparently have escaped passively through the vessel wall; and occasionally there is a slight perivascular infiltration by lymphocytes, plasma cells, and rare endothelial cells.

In the mid-brain, however, including the caudate and lenticular nuclei regions, and in the substantia nigra we find much more advanced changes. Here the perivascular mantling with inflammatory cells is prominent, although it may range from a localized group of cells at one point to a complete mantling with ten or more layers of round cells. Photomicrographs show these perivascular lesions (Plates 1 and 2).

In the cervical cord there is still another feature which occurs with considerable regularity. This is the diffuse infiltration of the gray matter, especially of the posterior horns. Plate 1, fig. 2, illustrates this point particularly well.

The nerve-cell lesions vary, and as a rule are very slight. Occasionally there seems to be complete loss of function and even death of the cell, but so rarely as to attract especial notice, again quite in contrast to anterior poliomyelitis. The changes, when they do occur, are usually first of a chromatolytic type, followed by swelling of the cytoplasm and nucleus and gradual karyolysis. In exceptional instances phagocytosis of these injured nerve cells and their fibers can be noted—neuro and neuronophagy—as it has been concisely termed. These nerve-cell changes are, I think, best studied in the sections of spinal ganglia.

The bacteriological findings in these cases are being reported in a separate paper. Suffice it to say here that morphological studies did not demonstrate any organisms in the tissues by either Giemsa or Gram-Weigert tissue staining. Cultural and inoculation methods proved more valuable in this respect.

A feature of the pathology in this particular group of cases has been an unusual skin exanthem. Of the cases from the Philippine General Hospital six have presented this picture. I do not wish to encroach on the clinician in discussing the relation of this lesion to the disease, but a few words are necessary concerning its development in order to discuss its histopathology. I have seen the lesions in four other cases, aside from this hospital group. It has always been one of the earliest objective symptoms of the cases when it occurred, and in at least three cases it was the reason for calling the physician or going to the hospital.

Characteristically, the lesions start as a dull, dusky red, macular eruption or mottling of the skin of the face and neck. This proceeds slowly downward over the trunk and upper extremities and then finally extends over the thighs, rarely getting below the knees. As the lesions develop they become discrete and punctate, almost papular in appearance, but retain their dull color. In respect to the distribution and the earliest appearance of the lesions one's first thought is measles. As they develop, however, the individual lesions, except for the color which persists as a somewhat dusky red, much more closely resemble the punctate rash of scarlatina. This stage of the lesion apparently takes from twenty-four to seventy-two hours to develop; and, while the neck lesions may become distinctly punctate and discrete, those of the trunk may just begin to show the dull mottling of the first stage.

The lesion undergoes a further development, with the formation of a tiny vesicle, not unlike the early lesion in varicella. This surmounts the papule and has almost no areola of inflammatory redness. It is only from 1 to 2 millimeters in diameter at the most, very superficial in character, and filled with what appears grossly to be a perfectly clear serum. Occasionally the vesicle becomes slightly umbilicated. It takes from forty-eight to ninety-six hours for these lesions to develop to their height, and there is the same progression from the head downward, those on the neck and shoulders appearing first. The lesions remain in this condition usually for several days and then, gradually, the serum within the bleb is absorbed and the necrotic cornified superficial epithelium is desquamated as a fine, barely visible furfuraceous scale. Plates 3, 4, and 5 illustrate the later stages of this rash. The photography was exceptionally difficult, owing to almost continuous involuntary myoclonic spasms of the various muscle groups.

In the literature of encephalitis which is available here, I have not been able to find any descriptions of strictly comparable skin lesions. It might readily be grouped as a disease entity, and were it not for the confirmatory evidence of "so-called" encephalitis, I should feel distinctly uncertain as to its relationship. The course of the lesions is readily divided into four periods: (*a*) the diffuse measleslike macular eruption, (*b*) the localizing scarlatina-form punctate papule, (*c*) the varicellalike vesicle formation, and (*d*) the period of desquamation.

I was fortunate in securing material from two of these cases within a short time of death and thus was able to study the histopathology of the lesions in their vesicular and desquamating stages. Unfortunately, none of the earlier lesions were examined microscopically. The vesicles are found to be absolutely superficial in character, with elevation of the cornified layer of the epithelium, the space being distended with coagulated, pink-staining, granular serum. The squamous cell layer appears entirely normal, as does the basement membrane. The normal prolongation of the epithelium into papillæ is noted, reaching well toward the corium. The sections studied were entirely free from hair follicles.

The corium itself shows dilatation of the terminal capillaries and an almost negligible amount of mononuclear perivascular infiltration. These cells are chiefly lymphocytes with an occasional eosinophile and plasma cell. No other polynuclears are seen, and no evidence of phagocytosis is noted. There is no tissue destruction or necrosis present, and no organisms are found in the deeper tissues by the commoner staining methods, such as Giemsa, Gram-Weigert, and Goodpasture's fuchsin. In one of the blebs itself a few barely visible coccoid organisms are seen, identical morphologically with the organisms obtained culturally from the central nervous system. Of course, no definite significance can be attached to such a single observation. The further discussion of the bacteriological findings will be taken up in a separate paper.

The presence of this skin eruption in relation to encephalitis of epidemic form is so striking and unusual a feature of the disease as to be worthy of some comment. The literature of encephalitis has been so profuse during the past three years that it is quite possible that I have overlooked references to a similar occurrence. Barker,(4) in a paper on diagnostic criteria in epidemic encephalitis, makes no mention of it, as is the case in the reports by European observers that I have been able to obtain. There are a few instances in the literature in which comment is made on the possible relationship of herpes, poliomyelitis, and encephalitis,(9, 21) based on the lesions of the spinal ganglia apparently. These do not accord in description with the lesions in this group of cases. Striking, too, is the preponderance of the hyperkinetic or myoclonic form of the disease in this series. Whether or not there may be some relationship in this respect is difficult to decide. This, likewise, suggests the possibility of whether these various clinical forms of the disease may not be due to different strains of the infecting organism which we are as yet unable to differentiate.

SUMMARY AND CONCLUSIONS

A report of an epidemic of so-called encephalitis lethargica, chiefly of the myoclonic form, is presented, covering personal observations on nearly fifty cases.

The epidemic was widespread in its distribution although relatively restricted in extent. A survey of the epidemiological data gives us little information as to the methods of dissemination, but apparently excludes influenza as a necessary precursor.

The clinico-pathological findings are of very little diagnostic value, except in a negative way. The spinal fluid usually shows a slight increase in its reducing ability on addition of copper salts and there is a tendency for a slight polynuclear leucocytosis in the blood picture.

The gross pathological changes are very slight, often negligible, consisting principally of generalized visceral and central nervous system congestion with occasional visible punctate hæmorrhages of the corpora striata, medulla, or cervical cord.

The histological changes are similar to those reported elsewhere by other workers; namely, perivascular infiltration of the central nervous system with lymphocytes, plasma cells and large mononuclear leucocytes, occasional capillary hæmorrhages, and rare nerve-cell degeneration.

An unusual skin lesion in ten cases is discussed. It passes through four stages—macular, papular, vesicular, and furfuraceous—and is diagnostic when present.

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ILLUSTRATIONS

PLATE 1

FIG. 1. Capillary hæmorrhage in III cranial nerve nucleus. Autopsy 9509.
2. Diffuse infiltration of the posterior cervical cord horn as well as the perivascular "mantle" of lymphocytes. Autopsy 9509.

PLATE 2

FIG. 1. Large capillary, showing perivascular lymphocytic infiltration. Autopsy 9565.
2. High-power photomicrograph, showing the lymphocytic mantling of the venous capillaries. Autopsy 9565.

PLATE 3

Chinese mestizo, 17 years of age, showing diffuse distribution of the skin lesions in encephalomyelitis.

PLATE 4

Near view of the case illustrated on Plate 3, showing the vesicles on the posterior surface of the right shoulder.

PLATE 5

Filipino, 18 years old, posterior view, showing the late desquamating furfuraceous stage with the typical shoulder distribution of the lesions in encephalomyelitis.

TEXT FIGURE

FIG. 1. Chart showing morbidity and mortality of epidemic encephalitis, Manila, 1922 and 1923.

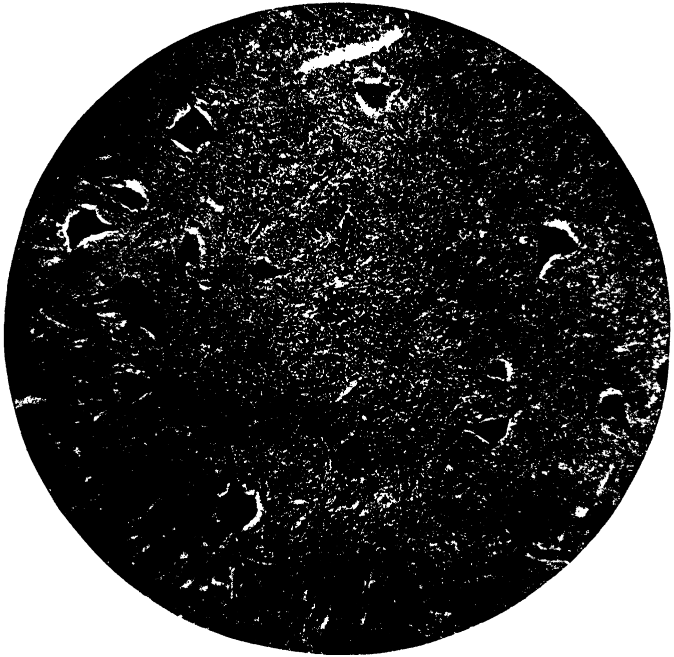


Fig. 1. Capillary hæmorrhage in III cranial nerve nucleus.

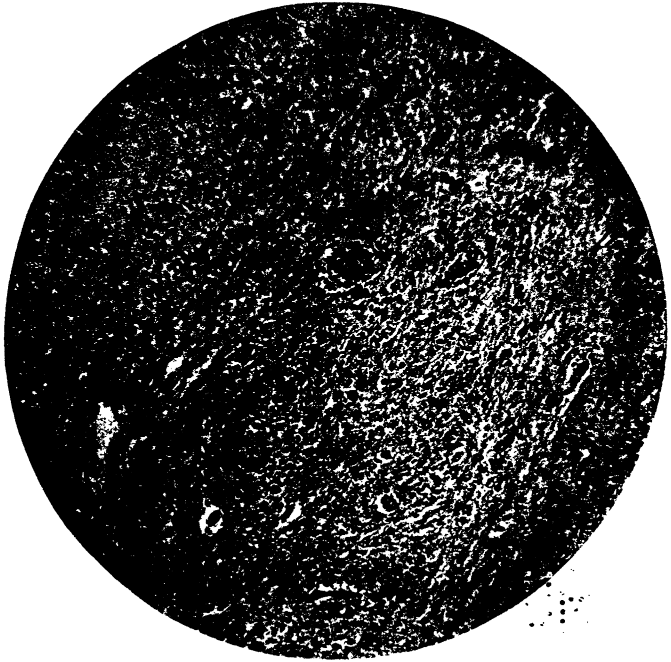


Fig. 2. Diffuse infiltration of the posterior cervical cord horn as well as the perivascular "mantle" of lymphocytes.

PLATE 1.

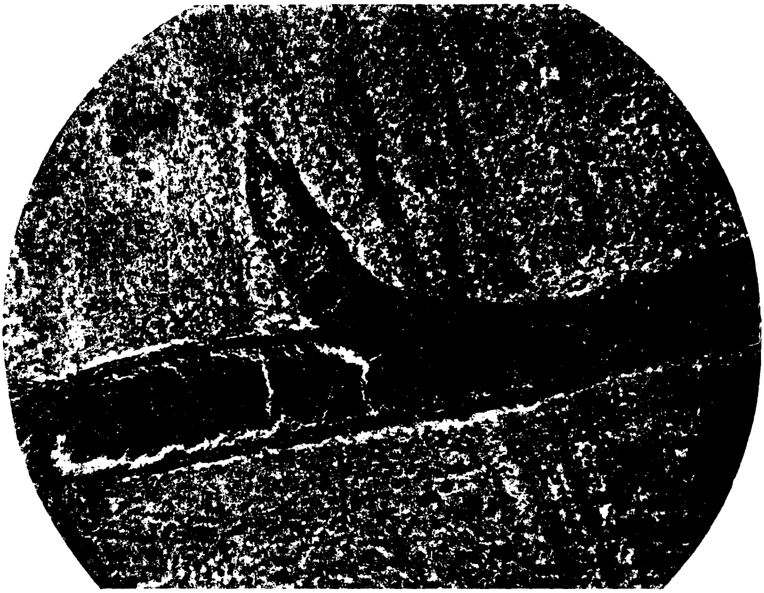


Fig. 1. Large capillary, showing perivascular lymphocytic infiltration.

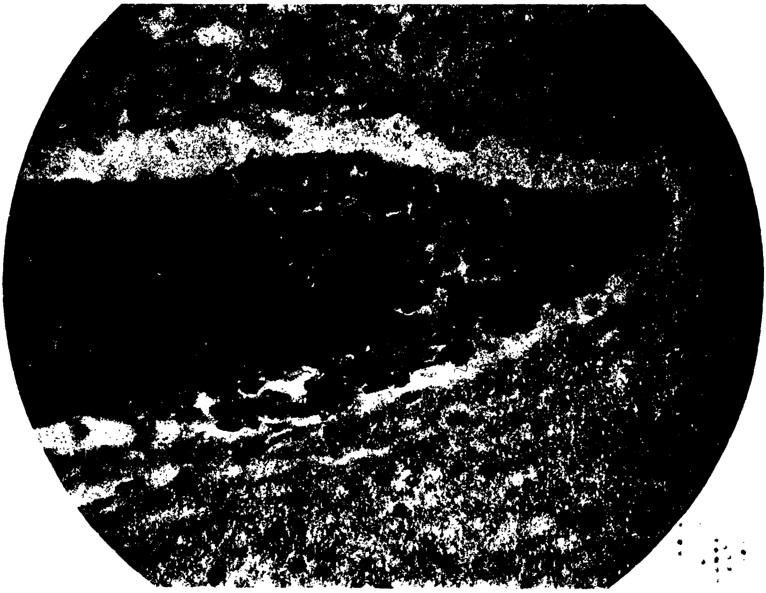
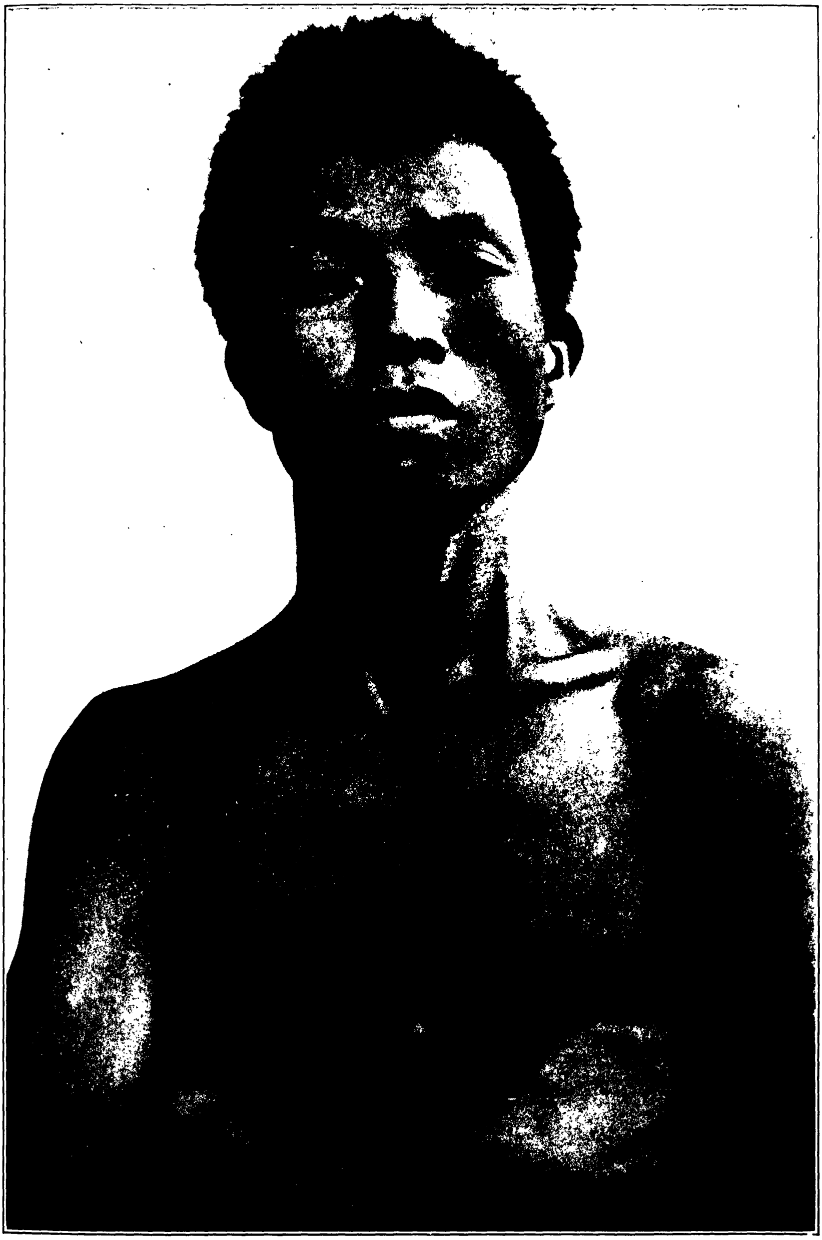


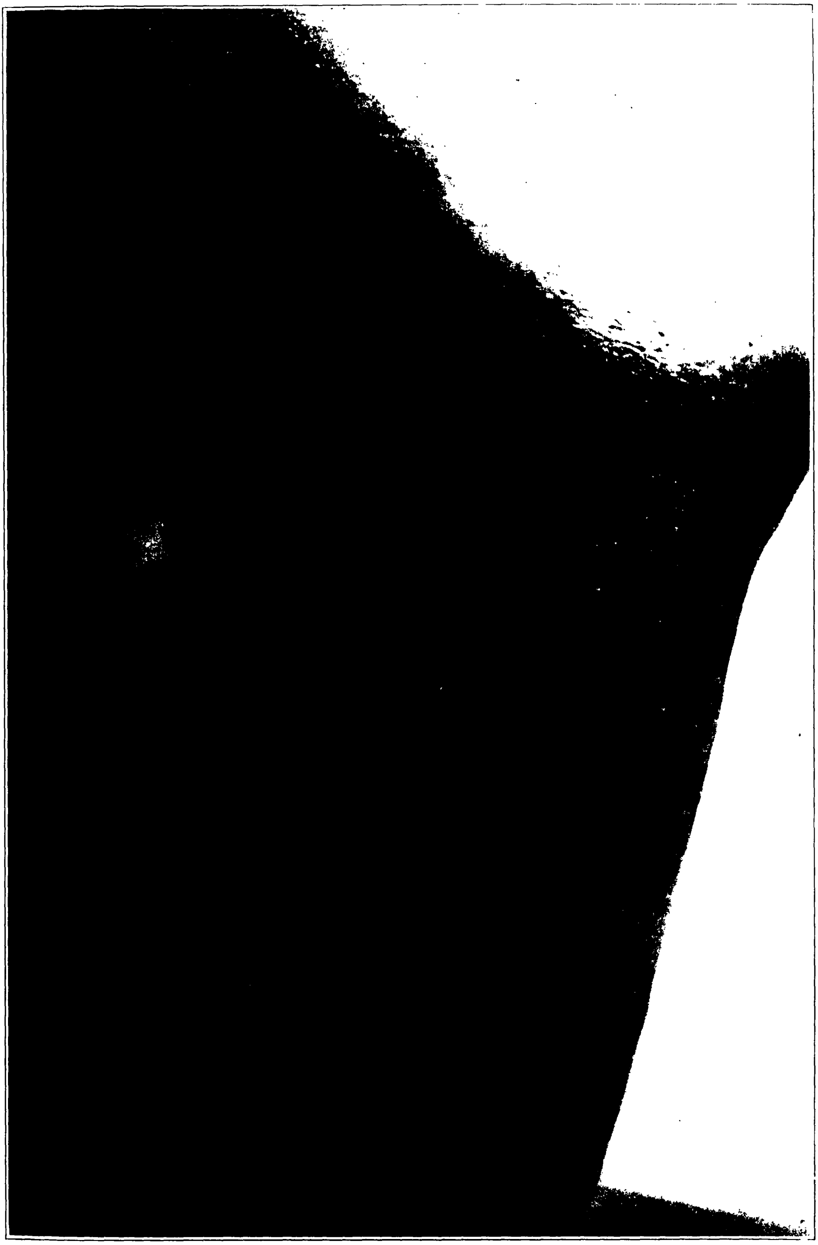
Fig. 2. High-power photomicrograph, showing the lymphocytic mantling of the venous capillaries.

PLATE 2.



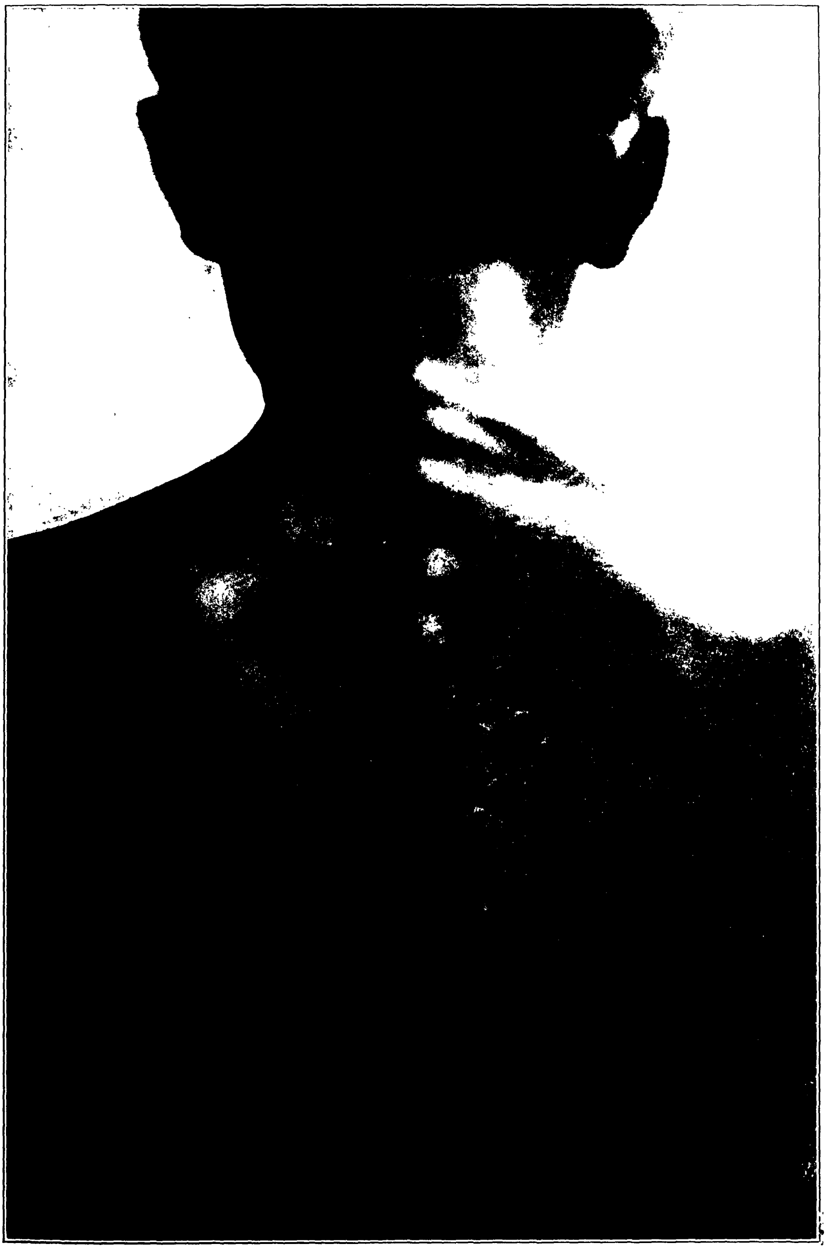
Chinese mestizo, 17 years of age, showing diffuse distribution of the skin lesions in encephalomyelitis.

PLATE 3.



Near view of the case illustrated on Plate 3, showing the vesicles on the posterior surface of the right shoulder.

PLATE 4.



Filipino, 18 years old, posterior view showing the late desquamating furfuraceous stage with the typical shoulder distribution of the lesions in encephalomyelitis.

PLATE 5.

CHEMOTHERAPEUTIC EXPERIMENTS WITH CHAULMOOGRA AND ALLIED PREPARATIONS

II. COMPARISON OF THE ANTISEPTIC POWER OF CHAULMOOGRA OIL WITH THAT OF OTHER VEGETABLE AND ANIMAL OILS, RARE AND COMMON

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Having obtained the desired information from preceding experiments as to the growth-inhibiting activity of chaulmoogra and related oils, and having by a different method arrived at the same conclusions as did Walker and Sweeney, I have attempted to survey as many vegetable oils, both common and rare, as were available, to see if any of them exert action similar to that of chaulmoogra; namely, a specific inhibition of the growth of acid-fast bacilli.

Certain oils of animal origin have been included, for the reason that they are similar in a way to cod-liver oil which, as is known, has been both recommended and in use in the treatment of tuberculosis and leprosy. A certain amount of information as to the origin and composition was necessary, for the collection contains some little-known oils. We were fortunate in securing the coöperation of the botanists and chemists of the University of the Philippines and of the Bureau of Science, who supplied us with the necessary data and with samples of the oils.

The technic followed in these tests was the same as the one described in the previous paper.[2] The same culture of *Bacillus tuberculosis* and the same medium, glycerine meat infusion agar, were used as before.

The growth was recorded in two and again in four weeks after planting in the case of *Bacillus tuberculosis*, and after forty-eight hours' incubation in the case of *B. typhosus*, *Vibrio choleræ*, and *Staphylococcus*. With the last-mentioned cultures only one dilution of the oils was made (0.5 per cent) and only complete inhibition of growth was considered. It should be em-

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[1] Member, Philippine Leprosy Research Board.

[2] Philip. Journ. Sci. 23 (1923) 533 to 542.

TABLE 1.—*Showing results of experiments with various oils.*

[+, growth as good as control; —, no growth in forty-eight hours; 0, not tested; ∠0. 1, less than 0.1 cubic centimeter; ∠1, less than one.]

Name of oil.	Scientific name of source.	Growth on agar containing 0.5 per cent of oil.			*Bacillus tuberculosis* growth inhibiting.	
		Vibrio choleræ.	*Bacillus typhosus.*	*Staphylococcus.*	Titer.	Value.
Chaulmoogra, India	*Taraktogenos kurzii*	+	+	+	0.005	20
Hydnocarpus wightiana	*Hydnocarpus wightiana*	+	+	+	0.001	100
Hydnocarpus venenata	*Hydnocarpus venenata*	+	+	+	0.005	20
Hydnocarpus subfalcata	*Hydnocarpus subfalcata*	+	+	+	0.005	20
Hydnocarpus alcalæ	*Hydnocarpus alcalæ*	+	+	+	0.005	20
Cashew	*Anacardium occidentale*	+	+	+	0.01	10
Citri microcarpus	*Citrus microcarpus*	+	+	+	0.05	2
Pinae sylvestris	*Pinus sylvestris*	+	+	+	0.05	2
Vetiver	*Andropogon zezanioides*	+	+	+	0.01	10
Caryophyli	*Eugenia caryophyllata*	—	—	—	0.05	2
Dacridylii	*Dacrydium*	—	+	+	0.01	10
Pittosporum	*Pittosporum resiniferum*	—	+	+	0.05	2
Cinnamon	*Cinnamomum zeylanicum*	—	—	—	0.001	100
Bergamot	*Citrus bergamina*	+	—	+	0.01	10
Eucalyptol	*Eucalyptus globulus*	+	—	+	0.05	2
Avocado	*Persea americana*	0	0	0	∠0.1	∠1
Bagilumbang	*Aleurites trisperma*	0	0	0	0.1	1
Betis	*Nadhuca betes*	0	0	0	∠0.1	∠1
Bayabac lard	*Varanus* spp	0	0	0	∠0.1	∠1
Calamus	*Acorus calamus*	0	0	0	∠0.1	∠1
Cedar	*Cedrela*	+	+	+	0.1	1
Ceara rubber	*Manihot glaziovii*	0	0	0	0.1	1
Coconut	*Cocos nucifera*	0	0	0	0.1	1
Cod liver	*Gadus callarias*	+	+	+	∠0.1	∠1
Corn, maiz	*Zea mays*	0	0	0	0.1	1

Odorata	*Gynocardia odorata*	+	+	+	∠0.1	∠1
Kalumpang	*Sterculia foetida*	0	0	0	∠0.1	∠1
Kamachile	*Pithecolobium dulce*	0	0	0	∠0.1	∠1
Kapok	*Ceiba pentandra*	+	+	+	∠0.1	∠1
Margosa	*Melia azadirachta*	+	+	+	∠0.1	∠1
Olive	*Olea*	+	+	+	∠0.1	∠1
Palm	*Elacis guineensis*	0	0	0	∠0.1	∠1
Palomaria	*Calophyllum inophyllum*	0	0	0	∠0.1	∠1
Peanut	*Arachis hypogaea*	0	0	0	0.1	1
Pili nut	*Canarium ovatum*	0	0	0	∠0.1	∠1
Sesamum	*Sesamum orientale*	0	0	0	∠0.1	∠1
Shark liver	*Stegostoma tigrinum*	+	+	+	∠0.1	∠1
Sindora supa	*Sindora supa*	0	0	0	0.1	1
Singkamas	*Pachyrrhizus erosus*	0	0	0	∠0.1	∠1
Turpentine	*Pinus* sp	0	0	0	∠0.1	∠1
Castor	*Ricinus communis*	0	0	0		Growth stimulating.
Lumbang	*Aleurites moluccana*	0	0	0		Do.

phasized that in these experiments glycerine meat infusion agar has been used as the culture medium to which the oils were added.

The bacteria other than *B. tuberculosis* were included in the test for the purpose of determining specificity or selective inhibitory power toward acid-fast bacilli in the case of a given oil which inhibited the growth of *B. tuberculosis* in at least as high a concentration as 0.5 per cent.

The collection contains forty-two different oils, including vegetable oils, essential oils, and animal oils, most of them found in the Tropics and also in the Philippines. The names, some of them local, indicate the source from which the oil is obtained. Scientific names of the plants and animals which yield the various oils are given in a separate column. They are arranged alphabetically in groups according to their growth-inhibiting effect, not as to their systematic or composition relationship. The figures given as growth-inhibiting titer indicate the amount of oil which, when added to 10 cubic centimeters of agar, still produced inhibition of growth of the culture; while the figures given as growth-inhibiting value express the relative strength of the inhibitory effect, 1 per cent concentration being taken as a unit.

It is evident from the results of the experiments shown in Table 1 that the oils investigated thus far can be classed into three groups, from the biologic standpoint. The first group contains oils which inhibit the growth on glycerine agar of acid-fast bacteria in comparatively small doses. This group can be subdivided into two; that is, oils which inhibit *B. tuberculosis* only and are indifferent as far as the growth of non-acid-fast bacteria is concerned and oils which inhibit the growth of *B. tuberculosis* and that of non-acid-fast bacteria.

The second group comprises oils which are indifferent as far as the growth of *B. tuberculosis* on glycerine agar is concerned; that is, when added to the culture media in small quantities such as were used in these experiments (1 per cent concentration), they do not influence the growth of acid-fast bacteria to any appreciable extent.

The third group consists of a few oils which, unlike those in the first group, seem to stimulate the growth on glycerine agar of *B. tuberculosis* in the concentration used rather than to inhibit it. That is to say, the growth appears more luxuriant and, in some cases, becomes perceptible sooner than in the control culture tubes containing glycerine and olive oil or glycerine only.

CONCLUSIONS

1. Certain vegetable oils, other than those containing the optically active fatty acids, inhibit the growth of acid-fast bacteria in vitro.

2. None of the vegetable oils proper that were investigated inhibit the growth of acid-fast bacteria to such a high dilution as do the chaulmoogra and *Hydnocarpus* oils which contain the optically active fatty acids.

3. Certain essential oils and oils containing volatile constituents show a very high selective inhibitory action upon acid-fast bacilli.

ACCESSORY LUNG, REPORT OF A CASE[1]

By ELOY V. PINEDA

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THREE PLATES

Accessory lungs occur so very rarely that it is deemed desirable to report the instance that occurred in the Philippine General Hospital, if for no other reason than to record the fact. This case was encountered in the course of a routine autopsy; it is the first to have been seen among the more than 9,700 autopsies that have been performed in the College of Medicine and Surgery, University of the Philippines. Cunningham,[2] commenting on the anomalies of the lungs, says that very few cases of accessory lungs have been found. The most recent report referred to in the scanty literature available here seems to be that of Cockayne and Gladstone[3] who found an accessory lung associated with hernia through a congenital defect of the diaphragm.

The commonest anomaly of the lung is abnormal or imperfect lobation, in either one or both lungs. Accessory lobes are also not infrequently found. Such findings as the presence of three lobes in the left lung, and two, or four, or more lobes in the right, are relatively common. An interesting anomaly in man is an occasional fourth lobe of the right lung, due to a rather deep indentation in the mediastinal surface caused by anomalies of the azygos vein, the so-called "lobulus Wrisbergi," or by the eparterial bronchial ramus arising directly from the trachea instead of from the main bronchus. This condition is normal in some of the lower animals, such as oxen and sheep.[4]

The case to be presented does not come under this category. There was present in the right pleural cavity a completely independent, functionless, accessory mass of pulmonary tissue. Both lungs were, anatomically speaking, normal in every respect.

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[1] Read before the Culion Medical Society, June 29, 1923. Observations made in the department of Pathology and Bacteriology, College of Medicine and Surgery, University of the Philippines.

[2] Textbook of Anatomy. Wm. Wood & Co., New York (1921) 1098.

[3] Journ. Anat. London 52 (1917) 64–96.

[4] Bailey and Miller, Textbook of Embryology. Wm. Wood & Co., New York (1911) 370.

The patient, J. M., a female Filipino infant, 5 months of age, was admitted to the surgical wards of the Philippine General Hospital on January 22, 1921, and died ten days later. The clinical diagnosis was acute cellulitis of the face, with septicæmia. There was nothing of importance in the history except that the mother was an inmate of the insane department of the San Lazaro Hospital.

Necropsy was performed eighteen hours post mortem.

The body was that of a small female Filipino child, 60 centimeters in length and 3.13 kilograms in weight. Development was rather poor, and nourishment was extremely poor. No anatomical abnormality could be found on careful external examination. The scalp was œdematous, and the superficial lymph nodes were rather prominent and palpable.

The subcutaneous tissue of the thorax and abdomen was œdematous and infiltrated, and a few pockets of pus were found.

The contents of the abdominal cavity showed nothing of interest. The organs were in a normal relation and none except the kidneys presented any gross pathological changes; these showed evidences of an acute parenchymatous nephritis. The heart and brain were normal.

In the superior mediastinum there were three fairly large, deeply congested, juicy lymph nodes, from the deep red cut surface of which blood exuded.

The lungs were normal in lobulation, but both showed bronchopneumonic changes.

Lying free in the right pleural cavity (Plate 1), resting on the posterior thoracic wall between the level of the sixth interspace and the eleventh rib, was a roughly oval mass that was deep red, firm in consistency, noncrepitant, with much the appearance of spleen tissue. This mass was 5.2 centimeters long, 3.1 centimeters wide, and 1.4 centimeters thick at its middle portion. Its lateral edge was smooth and thin, while the medial edge was thicker and had a slight indentation, a hilus through which the blood vessels and nerves entered. The superior pole was slightly less rounded than the inferior pole. The surface was slightly irregular, particularly posteriorly. The capsule was rather thick and showed fairly large blood vessels. The mass received its blood supply directly from the aorta by a relatively large branch, 1.6 centimeters in length and 0.6 centimeter in width, which sprang at right angles from that vessel at the level of the ninth dorsal vertebra. The vein from the mass emptied into the vena azygos at a slightly higher level. The nerve supply was traced from the sympathetic trunk at the sixth thoracic ganglion.

On section, macroscopically this organ showed a deep red glistening meaty surface with fairly large circular blood vessels from which a considerable amount of blood exuded on pressure. Pieces of the tissues failed to float on water.

Microscopically the organ was found to be practically identical structurally with an atelectatic lung of a new-born child (Plates 2 and 3). Bronchioles are present in large numbers, but they are without apparent order or arrangement; on the whole, they are strikingly large, as compared to the amount of alveolar tissue present. Fairly large ones are found close to the pleural covering, although the largest are near the hilum. In sections taken near the hilum the bronchioles are lined with ciliated pseudostratified columnar epithelium, resting on a distinct tunica propria. The band of circular muscle fibers is also present, although this is thinner and looser than in a normal lung. A few small, ill-developed mucous glands are present, but no cartilage can be found. The smaller bronchioles, in sections taken from the periphery of the organ, as in a normal lung, are devoid of glands and are lined with ciliated columnar epithelium. In many this is distinctly hyperplastic, so that the lumen is practically obliterated by the closely packed folds of mucosa. This shows signs of activity in the presence of a few goblet cells and a little coagulated albuminous material in the lumen.

The alveoli are for the most part small and completely collapsed. Those that are patent are very irregular in shape, and most contain a few desquamated epithelial cells. The alveolar walls are thick, some with an unusual amount of young connective tissue, and contain mononuclear wandering cells. The capillaries are dilated and engorged with erythrocytes. Proportionately enormous blood vessels with well-organized walls are seen in all the sections.

The pleural covering is thick, the layer of flat mesothelial cells resting upon a thick layer of young connective tissue that is continuous with the interlobular septa. This also carries blood vessels.

The large deep red glands in the mediastinum are found to have the histological characteristics of hæmolymph nodes.

COMMENT

We know that in its embryological development the lung begins as a median ventral longitudinal groove in the cephalic end of the foregut. This later becomes constricted in its posterior portion and grows caudally, becoming differentiated into the bronchi and lung buds. From the very beginning the right lung bud shows three different lobulations, while that of the left shows only two. This occurs with great regularity in man.

These early lobulations are maintained throughout the embryological period and determine the lung lobes. These structures continue growing in size and complexity until they are completely formed into the structure of the fully developed lung. Accessory lobes may be formed by further branching of the stem bronchus in the pulmonary wings, or by evagination from the original anlage, or as separate anlagen from the foregut.

In the present case it seems probable that, though it had completely separated from its point of origin, this accessory lung mass developed as a separate anlage. Had it been but an evagination of the pulmonary wing that was later constricted off, it seems likely that it would have been more closely related to, or would have retained some connection with, the lungs or bronchi, whereas it has absolutely no traceable communication with either. Furthermore, its blood supply would have come from the pulmonary artery, from an intercostal artery, or at least from high in the upper portion of the aorta as the bronchial arteries normally do. Actually, the pulmonary artery sends no branch into this mass and its blood is supplied by a short, disproportionately large vessel that arises directly from the aorta nearly as far back as the diaphragm. Its blood empties into the azygos vein. Its nerve supply comes from the right sympathetic trunk at the sixth thoracic ganglion. Therefore, it shows no arterial, venous, or nervous connection with the right lung which, except for a slight modification of shape incidental to the presence of the accessory mass in the same pleural cavity, was anatomically normal.

I wish to express appreciation for courtesies extended by Dr. H. W. Wade, chief pathologist of Culion Leper Colony, in connection with the preparation of this report.

ILLUSTRATIONS

PLATE 1

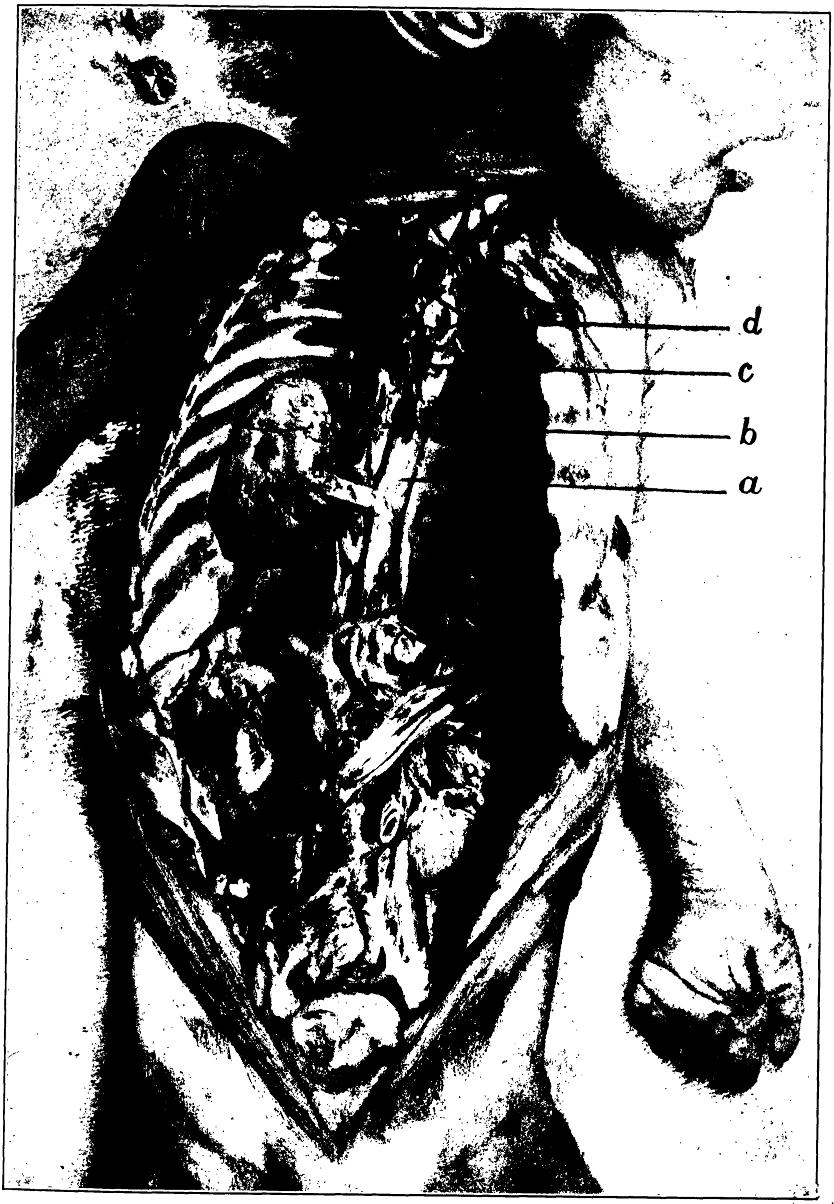
Body of child, showing the accessory pulmonary mass. *a*, aorta; *b*, azygos vein; *c*, sympathetic trunk; *d*, hæmolymph nodes.

PLATE 2

Section of the accessory pulmonary mass, showing a thick pleura, alveoli, alveolar walls, bronchioles, and blood vessels.

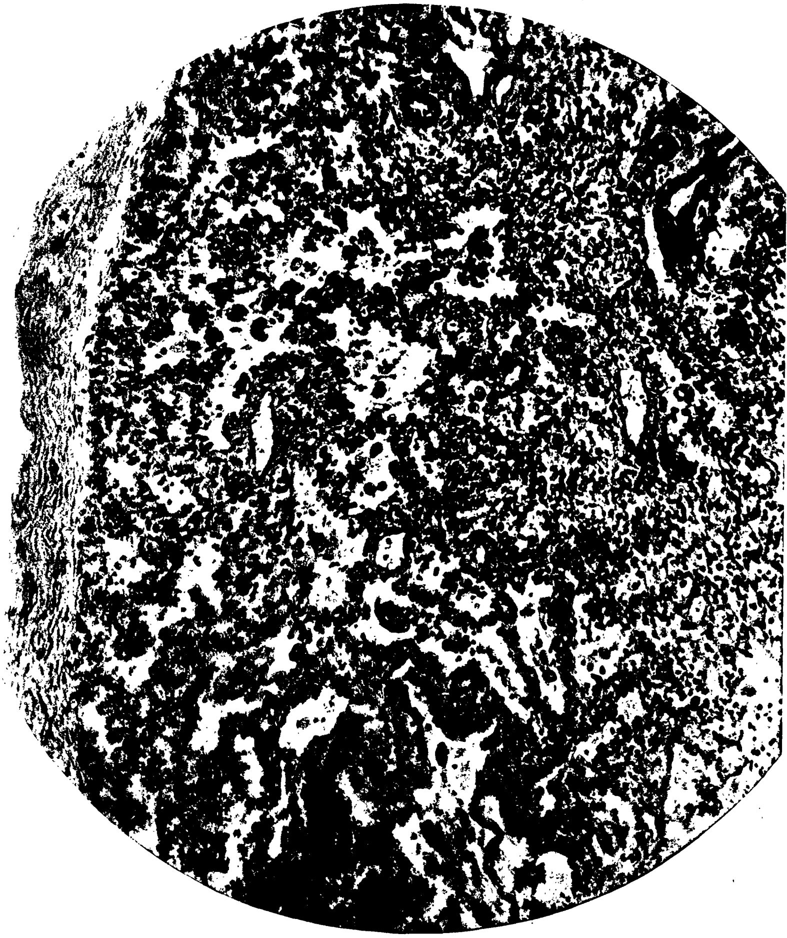
PLATE 3

Section of the accessory pulmonary mass, showing distinctly desquamated epithelial cells inside the alveoli; alveolar walls and engorged blood vessels.



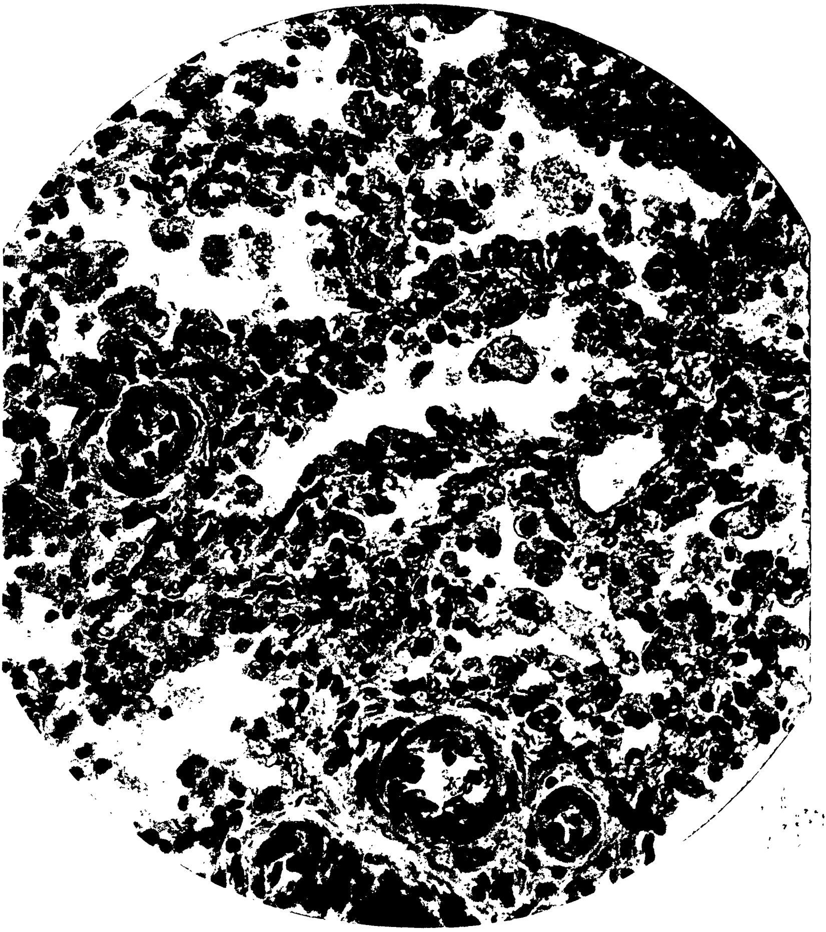
Body of child, showing the accessory pulmonary mass. *a*, aorta; *b*, azygos vein; *c*, sympathetic trunk; *d*, hæmolymph nodes.

PLATE 1.



Section of the accessory pulmonary mass, showing a thick pleura, alveoli, alveolar walls, bronchioles, and blood vessels.

PLATE 2.



Section of the accessory pulmonary mass, showing distinctly desquamated epithelial cells inside the alveoli; alveolar walls and engorged blood vessels.

PLATE 3.

THE VIABILITY OF INTESTINAL PATHOGENIC BACTERIA IN FRUITS AND PHILIPPINE FOODS EATEN RAW[1]

By ANA VASQUEZ-COLET

Of the Bureau of Science, Manila

Fruits and other articles of food eaten raw have often been blamed as being carriers of infectious material, and for this reason their sale in the public markets of Manila has in times of epidemic been forbidden. The purpose of the experiments here reported was to test the viability of three of the most important intestinal pathogens (*Vibrio choleræ, Bacillus dysenteriæ,* and *Bacillus typhosus*) in fruits and other articles of food eaten raw, especially by Filipinos, to determine what rôle they play in the spread of epidemics.

Consultation of the literature shows that a few experiments similar to these were undertaken by M. A. Barber[2] in connection with an experiment on cockroaches. He says:

> The longevity of cholera vibrios in cockroach fæces after discharge from the insect is probably short when the fæces are deposited in places where they can readily dry, but when discharged on moist food vibrios may remain for some time. To test this matter, some fresh cockroach fæces were placed on four different kinds of food: fresh beef, lettuce, fish, and clams. In every case, the cholera vibrios remained viable for at least sixteen hours at room temperature.
>
> In this connection it may be worth while to mention the results obtained by me in some recent experiments on the longevity of cholera vibrios in human fæces placed on various foods in use in this locality. Here, as in the case of the experiments with cockroach fæces, the cholera vibrios must compete with the other bacteria present in the fæces and with the microörganisms already present in the food. On the cut surfaces of a cucumber, a chico, and a papaya fruit—all distinctly acid to litmus—and on the leaves of lettuce, the cholera vibrios survived overnight in one experiment. In another test, cholera vibrios in human fæces survived twenty hours on the cut surfaces of cucumber and papaya fruits, but failed to live forty-four hours. On two varieties of shrimp, cholera vibrios in human fæces remained viable twenty-two hours; on oysters, forty-six hours; and

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[1] Read before the 19th Annual Meeting of the Philippine Islands Medical Association, December 21, 1922.

[2] Philip. Journ. Sci. § B 9 (1914) 1–4.

on the inside of an opened clam, four days. In all of these four foods, other bacteria were very numerous; in the oysters, especially, they were so plentiful that the food was acid in reaction when the cholera vibrios were placed on it. It is probably fair to assume that cholera vibrios, when abundant in cockroach fæces, would survive as long on foods as when in human fæces.

Filipinos are very fond of eating certain fruits and foodstuffs in a raw condition. Two such very favorite foodstuffs are *bagong* and *patis*. Bagong consists of very small shrimps pickled with salt. Patis is obtained from bagong by extraction and boiling. It is a dark brown salty liquid with a characteristic odor. The people obtain these two foodstuffs, already prepared, in the open market (where it is kept in open vessels, and handled freely without any particular regard to asepsis) and eat them without cooking. Certain dishes are more palatable when eaten in conjunction with bagong and patis. Certain cooked vegetables are nice to eat with bagong, while fish and meat are more palatable when dipped in patis. Native vinegar is a whitish, sour liquid, obtained by a process of fermentation from the nipa palm.

Presumptive tests and colony counts for bagong, patis, and native vinegar showed them to be negative for *Bacillus coli,* but very rich in bacteria. Bagong gave 100,000 colonies per gram; patis gave an innumerable bacterial count; vinegar had 34,000 bacteria per cubic centimeter; these were mostly yeast colonies.

The material used in my experiments consisted of fresh ripe fruits, bagong, patis, and native vinegar, obtained in the open market. The technic employed was simple. The fruits and the foods were distributed in wide-mouthed sterile bottles, one variety to a bottle. The reaction of the fruits to litmus was tested; they were all acid. Cultures of the given bacteria emulsified in sterile, distilled water were introduced into the bottles by means of a sterile pipette, or were smeared on the fruits by means of sterile swabs, according to the experiment. In a few of the experiments the bacterial emulsions were mixed with fresh, human fæces, but in the majority of them this was omitted.

Tests were made according to the usual routine procedures for the isolation of these bacteria: enrichment, plating, fishing, agglutinating, and sugar reactions. The procedure was as follows:

The fruits and other foodstuffs were distributed in wide-mouthed, sterile bottles; they were contaminated with emulsions of the given bacteria prepared from eighteen- to twenty-four-hour-old cultures in agar. Some of the fruits were smeared over with the bacterial emulsions on the outside, others on the cut surface. In Table 1 the fruits contaminated on the outside are indicated by the word "outside," and those contaminated on the cut surface by the words "cut surface." From hour to hour and day to day (or every so many minutes, according to the experiment) transplants were made from the contaminated surfaces, and suspicious colonies examined for the corresponding bacteria.

The findings, as a whole, confirm the belief that fruits and other articles of food, eaten raw, may convey infection, but not to a marked extent, it would seem. It must be remembered that in these experiments the fruits and raw foods were heavily contaminated with pure bacterial emulsions, which does not happen under ordinary circumstances, and in spite of this the bacteria did not survive very long. It seems that the admixture of human fæces lessens the probabilities of survival for the cholera vibrio. In foods very rich in bacteria, like patis, the cholera vibrios cannot survive even one hour. The same is true of fermenting foodstuffs.

Experiments with the cholera vibrio show that it survives from four hours to one day, at least, in bagong; one hour in patis; in vinegar, at the end of one hour no cholera vibrio could be isolated. In native cheese (queso) the cholera vibrio will survive at least two hours. On the cut surface of mangoes, bananas, chicos, and lanzones the cholera vibrio survives at least one day; on the cut surface of guavas it survives at least five hours; on the cut surface of apples it seems to thrive well; at the end of six days the infected apples were still positive for cholera vibrio. On the outside of bananas the vibrio remains viable for at least two days; on the outside of lanzones, one day; and on the outside of apples, four days.

Similar experiments were performed with *Bacillus typhosus*. From bagong, contaminated with *B. typhosus,* the bacillus could not be isolated at the end of five minutes; in patis, it can survive at least one day; in vinegar, five minutes. In native cheese it is still viable at the end of two days. On the cut surface of mangoes, bananas, and guavas it survives at least one day; on that of chicos, two days; on the cut surface of lanzones, seven hours; on the cut surface of apples it remains viable for at least three days. On the outside of apples and lanzones, it survives seven hours; on that of bananas, six hours.

The viability of *Bacillus dysenteriæ* (Flexner and Shiga) in such foodstuffs was also tested. Bagong, contaminated with a Flexner strain, is negative for dysentery bacilli at the end of five minutes. The same is true of bagong contaminated with a Shiga strain. In patis, the Flexner strain can survive two hours, while the Shiga strain cannot be found at the end of five minutes. In native cheese the Flexner strain survives at least five days, and the Shiga strain two days. On the cut surface of mangoes *B. dysenteriæ* (Flexner) survives four hours; on that of bananas, one hour; on the cut surface of chicos, three hours. From the cut surface of lanzones no dysentery bacilli could be isolated at the end of one hour; on the surface of apples it survives for at least three days; on that of guavas, one day. On the outside of apples and lanzones it survives seven hours; on that of bananas, six hours. The Shiga strain seems not to thrive in these fruits. From both the cut surface and the outside of apples, bananas, guavas, and lanzones, contaminated with this strain, no bacilli could be isolated at the end of one hour.

The results obtained with the different bacteria are tabulated in Table 1. In this table the time recorded is the length of time after which the organism was not recovered.

TABLE 1.—*Results of exposure of certain Philippine fruits and other foods to three important pathogens.*

	Cholera vibrio.				Pure cultures.					
	Pure cultures.		Mixed with fæces.		*Bacillus typhosus.*		*Bacillus dysenteriæ.*			
							Flexner.		Shiga.	
	Days.	*hrs.*	*Days.*	*hrs.*	*Days.*	*hrs.*	*Days.*	*hrs.*	*Days.*	*hrs.*
Bagong	2			5		1	----------		----------	
Patis		2		1	2		----------		----------	
Vinegar		1		1		1	----------		----------	
Mango (cut surface)	2		----------		2			5		1
Banana (cut surface)	2			7	2			2		1
Banana (outside)	3		2		7			7		1
Chico (cut surface)	2		3		3			4		1
Lanzones (cut surface)	2		----------		1			1		1
Lanzones (outside)	2		----------		1		1			1
Apple (cut surface)	7		5		4		4			1
Apple (outside)	5		2		1		1			1
Queso		3	----------		3		6		8	
Guava (cut surface)	----------		----------		2		2			1
Guava (outside)	----------		----------		----------		----------			1
Chico (outside)	----------			7	----------				----------	

CONCLUSIONS

The cholera vibrio will survive on human food from a few hours to at least six days; when mixed with human fæces, its probabilities of survival seem to be much lessened.

The typhoid bacillus on human food will survive from a few minutes to at least three days.

The dysentery bacilli (Flexner and Shiga types) survive on human food from a few minutes to at least five days.

LARYNGEAL SYMPTOMS IN BERIBERI[1]

By Antonio S. Fernando

Of the Philippine General Hospital, Manila

Beriberi, a tropical disease, characterized by a multiple neuritis, the result of a certain kind of vitamine-deficient nutrition, occasionally gives rise to symptoms referable to the eyes or to the throat. The eye symptoms have been extensively studied in Japan, and in an article published by me in 1923[2] I attempted to give an account of my meager observations on the same symptoms as observed in the Philippine Islands. Laryngeal symptoms in the form of hoarseness and even aphonia have been observed in beriberi patients, in both infants and adults. In infants, aphonia has been observed so frequently that it is considered one of the most characteristic symptoms of infantile beriberi. It is observed especially in the later stage of the disease. In adults it is not so frequent as in children, although it does occur occasionally. Vedder, in speaking of this symptom in beriberi, says: "Aphonia is a peculiar symptom that requires mention for it occurs with some frequency in chronic cases. The speaking voice is lost and the patient can only whisper." It was described as early as 1642 by Bontius who said, "while suffering from this disease the sound of my voice was so feeble for a whole month that those sitting next to me could not understand me."

Both of the cases that came to my observation in the Philippine General Hospital were of the cardiac type of beriberi, with complaints of hoarseness. This was found to be due to vocal cord paralysis.

Case 1, B. R., male, Filipino, 19 years old, had been confined to the medical ward of the hospital because of beriberi of the cardiac type. After a month or so he was discharged improved, but the hoarseness that developed persisted. He then came to me in the eye, ear, nose, and throat clinic of the free dispensary of the hospital. Laryngoscopic examination showed complete paralysis of the left vocal cord. Other laryngeal structures

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[1] **Received for publication August 24, 1923.**

[2] **See Elliot's Tropical Ophthalmology, Am. Journ. Ophthal. 6 (1923).**

appeared normal. X-ray of the chest was requested for discovery of possible aneurism of the aorta or of mediastinal tumor, but the roentgenologist reported as follows: "No changes of aneurism. General enlargement of the heart." In this connection it may be of interest to state here that in this hospital we very rarely observe aneurism of the aorta.

Case 2, C. P., female, 18 years old, admitted to the hospital because of acute beriberi, cardiac type, and acute cholecystitis; also referred to me by Dr. A. B. M. Sison because of the complaint of hoarseness. Examination showed total immobility of the left vocal cord. The other laryngeal structures were apparently in normal condition. X-ray of the chest showed enlargement of the heart.

In both cases the left vocal cord was the one paralyzed. It assumed the cadaveric position, remaining immobile during phonation, while the right cord came to the midde line and even a little beyond this. No changes of any importance were found in the other laryngeal structures.

Last year I saw a patient in the dispensary who complained of foggy vision. At that time, he was still being treated in the medical clinic for beriberi. He gave a history of having had hoarseness while suffering from numbness of the legs and dyspnea on slight exertion. He said he had been under antiberiberi treatment for some time and that his voice improved with the improvement of the other symptoms of the disease. Could not the laryngeal symptom in this case be secondary to the general disease from which the patient was suffering?

Now, among infants in whom hoarseness and aphonia have been more constantly observed, I have not attempted any laryngoscopic examination to determine the lesion in the larynx, especially in the cords.

As to the cause of the vocal-cord paralysis in these cases I have nothing definite to offer. In reviewing several textbooks of laryngology I have not been able to find any reference regarding vocal-cord paralysis in connection with beriberi. To laryngologists in the Tropics, especially in this country where the disease is endemic, the recognition of such a condition is very important. It has been found that pressure on the recurrent laryngeal nerve by aneurism, by mediastinal tumors, and even by an enlarged heart (according to some) may give rise to paralysis of the vocal cords. In the cases here presented the first two conditions are ruled out by the X-ray examinations.

It appears from the records in the Philippine General Hospital that the fulminant type of the disease (which is almost always fatal, many patients lasting only a few hours) rarely gave rise to any form of laryngeal symptom. The heart enlargement in these cases is very marked, and if we presume that the paralysis of the vocal cords in beriberi is due to pressure by the enlarged heart it is but reasonable to expect more of these cases of hoarseness in this type of the disease.

In infantile beriberi the loss of voice is complete, and in such cases most probably both cords are paralyzed. This condition can hardly be brought about by pressure from an enlarged heart because of the higher position of the right laryngeal nerve. Vedder, an authority on beriberi, believes that the aphonia in this disease is "probably due to degeneration of the pneumogastric nerves thus causing paralysis of the laryngeal muscles." As beriberi is a condition characterized by multiple neuritis, I am also inclined to believe, with Vedder, that this laryngeal symptom may be secondary to changes in the nerve supplying the laryngeal muscles, such changes (degenerative) being similar to those observed in the other nerves. Further clinical observations of this symptom in beriberi, together with post-mortem microscopical study of the laryngeal nerves in those with symptom of hoarseness or of aphonia who have died, should be made, as it is only by this means that the question can be settled definitely.

NEW BUPRESTID BEETLES FROM THE PHILIPPINE ISLANDS, I

By W. S. FISHER

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In working over a collection of buprestid beetles collected on Sibuyan Island by Prof. Charles Fuller Baker, College of Agriculture, University of the Philippines, Los Baños, P. I., a few new species have been found; these are described in the present paper.

Through the kindness of Professor Baker, the types of the new species have been placed in the collection of the United States National Museum.

Chrysodema sibuyanica sp. nov.

Form oblong-oval, attenuate in front and more acuminate behind, moderately convex; when viewed in profile, ventral surface is nearly straight to apical third, then strongly arcuately attenuate to apex, and dorsal surface feebly arcuately rounded; head and scutellum cupreous; pronotum greenish blue, the reliefs cyaneous with a strong violaceous tinge, lateral margins narrowly aëneous posteriorly; elytra aëneo-brunneous, the reliefs bluish black; abdomen beneath bluish green, with a strong violaceous tinge, the segments transversely cupreous along base, giving them a banded appearance; balance of body beneath aëneo-viridis, with a strong violaceous tinge, becoming cupreous toward sides; legs bluish green, with a strong violaceous tinge.

Head nearly flat, with a deep concave impression on front and vertex, the concavity extending to margin of eyes, and with a longitudinal groove extending entire length, the groove rather deep on front, but becoming only feebly impressed on occiput; surface with two irregular ridges behind antennal cavities and rather densely punctate, the punctures deep and well separated on occiput, becoming finer and more inconspicuous in the concave area, sparsely clothed with fine, erect, cinereous hairs; epistoma broadly arcuately emarginate in front. Pronotum moderately convex, slightly more than one and one-half times as wide as long, narrower in front than behind, widest at base;

marginal carina not attaining apex; sides feebly arcuately narrowed from base to apex; anterior margin arcuately emarginate, with a broadly rounded median lobe; base feebly sinuate; surface somewhat rugose toward sides, with a feeble elongate impression extending from near base at middle of elytron obliquely to lateral margin near middle and replacing the usual deep fovea, and with a broad smooth median carina extending from base to anterior margin, deeply, coarsely punctate, the punctures very irregularly distributed, causing numerous irregular reliefs, which are shining, very finely punctured, and densely obsoletely granulose; surface also very sparsely clothed with short inconspicuous hairs. Scutellum wider than long, trapezoidal in form, widest at base; surface nearly smooth, with a small fovea at middle. Elytra rather strongly convex, without basal impressions, slightly wider than pronotum at base; sides feebly arcuate from base to near middle, where they are slightly sinuate, then arcuately attenuate to the tips, which are rather acute and armed with five strong, acute teeth, sides also more or less irregularly serrate near the middle; humeral angles broadly rounded; each elytron with four distinct broad costæ, not including the sutural elevation, which is feebly longitudinally divided behind scutellum; first costa entire, extending from base to apex and parallel to suture; second one feebly sinuate and extending from base to near apex, where it is connected to the first; third extending from near humeral angle to apical fourth and parallel to marginal costa; and a marginal one extending from humeral angle to apex and parallel with lateral margin; there is also indication of a short costa at base between second and third costæ; all of the costæ are about an equal distance apart, smooth, and with a few large punctures irregularly distributed; intercostal spaces rather densely punctate, the punctures large and irregularly placed, surface also very sparsely clothed with extremely short inconspicuous hairs, and somewhat transversely rugose behind the humeri, which are not prominent. Abdominal segments with a few large punctures on apical half, but densely and finely punctured along basal parts, where the surface is also rather densely clothed with very fine recumbent hairs; last segment strongly acuminate at apex, with a deep oval emargination at tip; there is also a shallow longitudinal impression extending from apical emargination to about middle of segment, where the surface is more finely and densely punctured, and with a dense bunch of long yellowish pubescence, which nearly conceals the emargination; balance of body beneath deeply and irregularly punctate, the punctures coarse and widely separated at middle, but becoming finer and denser at sides, where the pubescence is similar to that of the basal portions of abdominal segments; tarsi violaceous.

Length, 30 millimeters; width, 10.

Type locality.—Sibuyan Island, Philippines.

Type and paratype.—Catalogue No. 25949, United States National Museum.

Described from two specimens collected by Prof. C. F. Baker on Sibuyan Island (*Baker 18974*). The paratype is smaller than the type, measuring only 24 millimeters in length and 8 millimeters in width, and only differs from the type in a few small details, namely: The elytral costæ are of a more bluish green color, the elytra has the apex not as strongly toothed and the sides not serrate, and the apical emargination of the last abdominal segment is slightly smaller and not as deeply emarginate.

This species is very closely allied to *Chrysodema eximia* Castelnau and Gory in sculpture and outline, but can be easily distinguished from that species by the coloration.

Chrysobothris sibuyana sp. nov.

Female.—Form moderately convex, head cupreous, pronotum reddish cupreous, with the anterior edge narrowly margined with bright green, scutellum dark green, elytra purplish brown, becoming more bluish on disk; each elytron ornated with bright green spots as follows: A large area starting at basal impression, then covering humeral region and extending along side to near middle and terminating in a large round green fovea on disk just in front of middle; two small round green foveæ at apical fourth, which are placed transversely on disk and connected to each other on inner margin; sutural margin posteriorly and apex with a slight greenish tinge. Body beneath bright shining green with sides purplish cupreous and posterior margin of abdominal segments narrowly margined with blue; legs purplish cupreous, with base and dorsal side of femora greenish; tarsi cyaneous.

Head with front strongly triangular and surface sparsely clothed with a few inconspicuous cinereous hairs; occiput very narrow, longitudinally carinate, and surface irregularly, coarsely, and rather deeply punctate, the punctures becoming confluent along eyes; vertex with a broad transverse obtuse ridge, which does not protrude over front, nor extend to lateral margins; front broadly but not very deeply concave, the concavity somewhat irregularly concentrically striolate, the striæ widely separated and the intervals nearly smooth, with a few small, irregularly placed punctures, sides very coarsely and confluently punctate; eyes large and nearly contiguous on occiput; epistoma large, broadly and deeply arcuately emarginate in front; antennæ purplish cupreous, with the second joint slightly aureous. Pronotum strongly transverse, and moderately convex, twice as wide as long, front and base about equal in width; sides nearly parallel and bisinuate (obliquely expanded from anterior angles to apical sixth, then feebly arcuately emarginate to basal sixth, and finally obliquely narrowed to posterior angles, which are broadly obtuse); anterior margin with an obscurely rounded median lobe; base very deeply bisinuate, with a large broadly rounded median lobe, which is truncate in front of scutellum; surface without impressions, strongly, densely, and transversely rugose, the rugæ becoming more irregular toward sides, intervals sparsely irregularly punctate, the punctures becoming coarser and denser along lateral margins. Scutellum small, triangular, with the three sides about equal in length, and the surface obsoletely granulose. Elytra distinctly wider than pronotum at base, rounded at humeral angles and nearly parallel to apical third, then arcuately attenuate to tips, which are broadly rounded; lateral margins coarsely and irregularly serrate, the teeth becoming nearly obsolete on anterior half; base strongly lobed; surface nearly smooth and rather densely punctate, the punctures widely separated on disk, but becoming denser and coarser at base, apex, in the impressed areas and along lateral margin, where the surface is also feebly rugose, the rugæ becoming more distinct in the humeral regions; each elytron with two broad obsolete costæ on apical half, one along suture and the other along lateral margin, the costæ not extending to middle of elytron; there are also a deep impression at middle of base, a shallower one near humeral angle, a large round one on disk near middle, and two smaller round ones, transversely placed on disk at apical fourth. Abdomen beneath coarsely punctate, the punctures widely separated on median part, the surface becoming finely, longitudinally striolate along lateral margins and clothed with a few inconspicuous hairs; last segment deeply, broadly arcuately emarginate at apex, with a short obtuse tooth at middle of emargination and a strongly elevated longitudinal carina extending from apex to about middle of segment. Prosternum nearly flat, and very coarsely punctate, the punctures becoming transversely confluent on anterior part, the surface very sparsely clothed with long cinereous hairs. Femora robust, the anterior ones with a broad obtuse tooth on outer edge at apical third.

Length, 10.5 millimeters; width, 4.5.

Type locality.—Sibuyan Island, Philippines.

Type.—Catalogue No. 25947, United States National Museum.

Described from a single female from Sibuyan Island, collected by Prof. C. F. Baker.

This species is closely allied to *Chrysobothris pictiventris* Saunders, but is a much smaller species, the transverse carina on front of head is more obtuse, the pronotum more reddish cupreous and without the posterior angles aureous, and the base more deeply sinuate; elytra with the basal lobe more angulated, the green color on basal part more extended, the two spots at apical fourth connected and impressed, and the punctures more widely separated on the disk; the last abdominal segment more deeply emarginate at the apex, the median tooth not as long as the outer teeth, and the median carina extending to anterior margin of segment.

Philanthaxia cumingii var. **basalis** var. nov.

Oblong-oval, head and pronotum reddish cupreous, elytra reddish cupreous, becoming more brownish on disk and with basal third bluish green; surface above glabrous; beneath aëneous and sparsely clothed with very short, recumbent, cinereous pubescence.

Head strongly convex, transversely concave between antennæ; surface strongly reticulate, the reticulation forming a network of small irregular sunken areas, in the center of which is a small puncture; eyes large, prominent, extending slightly beyond pronotum on each side; epistoma wide, truncate in front. Pronotum convex, nearly twice as wide as long, distinctly narrower in front than behind, widest at base; sides obliquely attenuate from base to apex; anterior margin arcuately emarginate, with a feebly rounded median lobe; base transversely truncate; surface with an obsolete broad impression on each side near posterior angles, reticulation similar to that on head but becoming finer on anterior part of disk and more transverse in front of scutellum. Scutellum cordiform, truncate in front, wider than long; surface finely reticulate and strongly impressed at middle. Elytra about equal in width to pronotum at base; sides strongly expanded behind humeri, where they are distinctly wider than pronotum, nearly parallel to apical third, then obliquely attenuate to tips, which are separately, narrowly rounded; lateral margin finely serrate; base with a transverse impression, becoming deeper externally; humeri prominent; surface deeply and regularly striate, the striæ not quite reaching to apex, and becoming less distinct toward base; intervals flat, densely transversely rugose, rather densely finely punctate, and becoming finely scabrous at apex. Abdomen beneath densely and rather coarsely ocellate-punctate, becoming somewhat longitudinally rugose on last segment, which is broadly rounded at apex; posterior coxæ with posterior margin truncate; prosternum, mesosternum, and metasternum strongly and densely scabrous at middle; femora and tibiæ finely but not densely rugose.

Length, 7.2 millimeters; width, 3.25.

Type locality.—Sibuyan Island, Philippines.

Type.—Catalogue No. 25950, United States National Museum.

This variety is described from a single example from Sibuyan Island, collected by Prof. C. F. Baker. It differs from *Philanthaxia cumingii* Waterhouse in having the basal third of the elytra bluish green, and the eyes more projecting.

Cisseicoraebus bakeri sp. nov.

Form elongate, subcylindrical, broadly rounded in front and moderately attenuate behind; when viewed in profile the surface is nearly straight beneath and broadly arcuate above; golden green, with a slight cupreous tinge in certain lights. Each elytron narrowly margined with a cyaneous color and ornated with irregular cyaneous spots and fasciæ, these spots and fasciæ narrowly margined with a lighter shade of blue and arranged as follows: Three spots along suture, the first one a little behind scutellum, an oblong one near middle, and a smaller one at middle slightly in advance of the first transverse fascia; a broad transverse fascia just behind middle, extending from lateral margin to middle of disk and connected to a very narrow oblique band, which extends backward to suture midway between the two transverse fasciæ; a broad transverse fascia at apical fifth extending from lateral margin to suture; along lateral margin there are also an oblong spot at basal third and a small round one midway between the two transverse fasciæ. Beneath golden green with a slight cupreous reflection; tarsi piceous.

Head nearly flat, with a broad, moderately deep longitudinal groove extending from occiput to a deep transverse groove in front of epistoma; surface sparsely but coarsely and irregularly rugose on front, and coarsely punctate, the punctures deep and irregularly placed, forming numerous irregular impunctate areas, and sparsely clothed with a few inconspicuous recumbent hairs arising from the punctures; epistoma smooth, concave, and very broadly arcuately emarginate in front, the emargination feebly sinuate at middle; eyes large, elliptical and parallel on front; cheeks armed with a large tooth, which is rather acute at apex. Antennæ piceous (first joint aëneous), reaching to middle of pronotum and serrate from the fourth joint; first joint clavate and feebly arcuate; second elongate, cylindrical; third shorter and slenderer; following joints triangular, except the last one, which is oblong and acute at apex. Pronotum strongly transverse and moderately convex, nearly twice as wide as long, base and apex about equal in width, widest at middle, with a broad shallow impression on each side of disk near apical margin, and a broad, irregular one on each side along lateral margin, and also with a broadly concave impression along base, which does not extend to lateral margins, and leaving an obsolete elevated area near posterior angles, but without a distinct lateral carina; sides broadly arcuately rounded, with the margins feebly irregularly crenulate; posterior angles broadly rounded; anterior margin deeply arcuately emarginate, with the median lobe broadly rounded and the anterior angles acute; base deeply sinuate, with a broad median lobe, which is truncate and feebly emarginate in front of scutellum; surface coarsely and irregularly punctate, the punctures deep and connected to each other in irregular series by deep sinuate grooves, irregularly distributed, the grooves becoming somewhat concentrical on disk, and from each puncture arises an inconspicuous recumbent cinereous hair; intervals smooth and shining. Scutellum subcordate, acuminate at apex; surface finely densely reticulate, with a few coarse punctures in middle. Elytra moderately convex, feebly flattened near apex, about equal in width to pronotum at base, with a rather deep basal impression, and a narrow, deep groove, extending from the humeral angles to middle of elytra; sides sinuate in front of middle, slightly expanded at anterior transverse fascia, then obliquely attenuate to tips, which are obliquely truncate, rounded at sutural angles, and with the margins strongly dentate, the teeth becoming more irregularly placed and less distinct along anterior half of elytra; humeral angles obtusely angulated; humeri prominent; surface strongly and densely rugose, the rugæ shining and more elevated and transverse on the golden green areas, with the impressions coarsely and rather densely ocellate-punctate, sparsely clothed with rather coarse recumbent hairs, which are cinereous on the golden green areas and black on the cyaneous spaces. Abdomen beneath deeply and rather densely punctate, the punctures smaller at apex and connected to each other by a sinuate groove on the lateral parts of segments, sparsely clothed with recumbent cinereous hairs, the hairs becoming denser toward sides of segments; last ventral segment broadly rounded and subtruncate at apex; posterior coxæ more densely pubescent than rest of body. Mesosternum and metasternum coarsely punctate, the punctures connected by coarse sinuate grooves. Prosternum uneven, declivous in front; anterior margin with a narrow lobe, which has the anterior margin broadly arcuately emarginate, forming a strong toothlike lobe on each side; prosternal process flat, broadly rounded at apex, the surface with vermiculate grooves, in the bottom of which are numerous moderately deep punctures, from the center of which arises a semi-erect cinereous hair. Legs finely densely reticulate, and sparsely scabrous; tarsal claws bifid, inner tooth about one-half as long as outer one, and acute at apex.

Length, 14 millimeters; width, 4.75.

Type locality.—Sibuyan Island, Philippines.

Type.—Catalogue No. 25948, United States National Museum.

This beautiful species is described from a single specimen from Sibuyan Island, collected by Prof. C. F. Baker (*Baker 18977*).

This species, in color and markings, resembles somewhat *Polyonychus nigropictus,* described by Castelnau and Gory from India, but is separated from that species by the eyes being parallel and not oblique, and the prosternal lobe being armed with a large tooth on each side, while in *P. nigropictus* the lobe is entire. Kerremans erected the genus *Cisseicoraebus* for three species, *grandis* Kerremans, *retrolatus* Deyrolle, and *subcornutus* Fairmaire. From *subcornutus* it is easily separated by not having the head tuberculate, and from *grandis* and *retrolatus* by the pronotum not being densely pubescent, and by the coloration and markings on the elytra.

EINIGE NEUE ANOMALA-ARTEN DER PHILIPPINEN

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Anomala vigilax sp. nov.

Zur Gruppe der *varicolor* Gyll. gehörend. Gestreckt oval, hinten kaum verbreitert, ziemlich hoch gewölbt. Oben und unten gelbbraun, der Kopf, die Scheibe des Thorax und das Schildchen dunkler braun mit grünem Erzschiller, die Seiten der Deckflügel, die Tibien und Tarsen braun; Oberseite glänzend, kahl, nur die Seiten des Halsschildes und der Deckflügel, die Unterseite und Beine mit langen rotbraunen Haaren. Kopfschild fast parallelseitig mit hoch aufgeworfenem Rand, wie die Stirn leicht vertieft, dicht und kräftig runzelig, Scheitel, Halsschild, und Schildchen kräftig einzeln punktiert, Halsschild mit Seitengrübchen und einem kurzen schiefen Eindruck dahinter; basale Randfurche nicht unterbrochen. Auf den Deckflügeln sind die primären Punktreihen regelmässig gefurcht, die Rippen kaum höher als die Interstitien, von den letzteren das subsuturale unregelmässig punktiert, das zweite und dritte mit je einer einfachen Punktreihe. Afterdecke dicht und fein runzelig mit einzelnen grossen haartragenden Ringpunkten dazwischen. Vorderschienen ohne Andeutung eines zweiten Seitenzahnes. Beim ♂ ist an den Vorderfüssen die innere (grössere) Klaue einfach, an den Mittelfüssen die äussere gespalten; die Fühlerkeule so lang wie die Geissel.

Länge, 12 Millimeter; Breite, 6; ♂.

LUZON, Provinz Benguet, Trinidad, 6,000 Fuss, Mai, 1914 *(G. Boettcher)*.

Anomala apogonioïdes sp. nov.

Aus der Verwandtschaft der *leotaudi* Bl., in Körperform und Färbung einer *Apogonia* ähnlich. Gestreckt oval, ziemlich stark gewölbt, oben und unten gleichmässig dunkelbraun mit kupfrigen Bronzeschimmer, schwach glänzend, nur die Fühler braungelb. Kopfschild und Stirn dicht runzelig, Scheitel, Halsschild und Schildchen dicht und ziemlich kräftig einzeln punktiert, die beiden letzteren mit angedeuteter Mittelfurche, die basale Randfurche in der Mitte nicht unterbrochen. Auf den Deckflügeln sind die primären Punktreihen leicht gefurcht, die Interstitien unregelmässig punktiert, die ganze Oberfläche mit feinen Pünktchen überstreut. Die Afterdecke ist sehr dicht und fein gerunzelt, neben der etwas höckerigen Spitze beiderseits leicht eingedrückt, mit einzelnen langen Borstenhaaren. Abdominalsternite und Hinterbrust mit einzelnen grossen Ringpunkten, aus denen gelbe Borsten entspringen. Vorderschienen mit spitzem Spitzen- und Seitenzahn. Forceps ähnlich dem der *leotaudi.*

Länge, 13 Millimeter; Breite, 6.5; ♂.

MINDANAO, Provinz Surigao, Surigao, 21 Mai, 1915 (*Boettcher*).

Anomala quadricalcarata sp. nov.

Zur Gruppe der *sulcatula* Eschsch. gehörend. Gestreckt oval, rotbraun bis schwarzbraun mit grünem Erzschiller, Oberseite kahl, lebhaft glänzend, Unterseite und Beine graugelb behaart. Kopf und Kopfschild, Thorax und Schildchen sind dicht und Kräftig punktiert. Auf den Deckflügeln sind die primären Punktreihen ganz regelmässig, an den Seiten und beim Hinterrand leicht gefurcht, auf der Scheibe hinter dem Schildchen ist die Punktierung flacher und durch feine Querrunzeln unterbrochen; die zweite primäre Rippe trägt eine unregelmässige Punktreihe von der Basis bis zum Hinterrand, die dritte innen neben der Schulter nur einige wenige Punkte. Afterdecke dicht und fein runzelig, matt. An den Vorderschienen ist der Seitenzahn klein, aber scharf, der Spitzenzahn beim ♂ kurz und spitz, beim ♀ etwas länger, leicht gerundet, nicht verbreitert. Bei ♂ und ♀ sind an den Hinterbeinen die Trochanteren verlängert, scharf vorspringend, die Tibien auf der Mitte der Innenseite mit einem grossen Zahn versehen. Der Forceps ist ähnlich dem der *sulcatula*, es fehlt jedoch auf der Aussenseite der Parameren die gebogene Kante.

Länge, 12 bis 14 Millimeter; Breite 6.5 bis 7; ♂, ♀.

SIBUYAN (*Baker*).

Anomala (Spilota) moseri sp. nov.

Zur Gruppe der *picturata* Cand. gehörend. Oberseite rotgelb und schwarz, Unterseite hellgelb mit einigen schwarzen Flecken. Kopfschild und Kopf rotgelb, nur auf dem Scheitel zwei kleine punktförmige schwarze Fleckchen; Kopfschild und Stirn dicht runzelig, matt, der glänzende Scheitel mit einzelnen feinen Punkten. Halsschild rotgelb mit fünf schwarzen Flecken, zwei streifenförmigen an den Seiten, die weder den Vorder- noch den Hinterrand berühren, zwei dreieckigen auf der Scheibe neben der Mittellinie, und einem grossen an der Basis in der Form eines lateinischen V; die Punkte sind an den Seiten grob und dicht, auf der Mitte fein und einzeln. Schildchen schwarz mit einigen feinen Pünktchen an der Basis. Deckflügel schwarz, ein Querstreifen an der Basis, eine zackige Querbinde, die vom Aussenrand neben und hinter der Schulter bis zur Spitze des Schildchens zieht, und eine in einzelne Fleckchen aufgelöste Querbinde hinter der Mitte rotgelb; die primären Punktreihen sind tief gefurcht, primäre Rippen und Interstitien gewölbt, im subsuturalen Interstitium eine Punktreihe von der Basis bis zum Hinterrand, im zweiten Interstitium einzelne grobe Punkte. Propygidium schwarz mit zwei kleinen hellgelben Flecken an der Seite; Pygidium schwarz mit breitem gelbem Mittelstreifen. Unterseite hellgelb, ebenso die Beine, nur die Schenkel mit einem schwarzen Fleck; die Spitze der Hinterschienen und alle Tarsen schwarz.

Länge, 13 Millimeter; Breite, 7; ♂.

MINDANAO, Provinz Surigao, Surigao *(Boettcher)*.

THE GENUS MAKILINGIA (JASSOIDEA) IN THE PHILIPPINES

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TWO PLATES

Makilingia,[1] which is a member of the Gyponidæ, subfamily Sudrinæ, is undoubtedly a sudrine gyponid, instead of hylicine, as stated in my original paper. Since 1914 considerable additional material has accumulated, and it is now possible to present a more comprehensive treatment.

The five species first described came from the two great mountains of central Luzon, Maquiling and Banahao. We now find that the genus is more richly represented in the mountains of northern Luzon,[2] but also may occur at low altitudes, as well as in other islands of the Archipelago, south to Mindanao. A few of the species are abundant and widely distributed, while the remainder appear to be of very local distribution, so far as present knowledge goes. The genus appears to be confined to the Philippines and even more peculiarly characteristic of this fauna than are the pachyrrhynchid beetles. Fifteen new species and varieties are here presented. Exploration of the vast unknown mountainous regions of the Archipelago will undoubtedly produce many more.

There is a superficial resemblance in general form, between this genus and the Japanese genus *Epiacanthus* of Matsumura,[3] but the latter possesses a totally different head structure and is, moreover, a tettigoniellid, not a gyponid.

In my earlier paper sufficient stress was not laid on the structure of the scutellum, which is highly characteristic of the genus. The raised apical portion is preceded by a wide transverse depression, very evident in lateral view (Plate 1, fig. 2, *b*). The fronto-clypeal suture is absent in all the species, the clypeus being relatively of great size. Also characteristic of the genus is the distally narrowed median apical cell (Plate 1, fig. 2, *b;* Plate 2, fig. 6, *c;* fig. 9, *b*). The ovipositor does not extend beyond the pygofers, and the genitalia are always considerably exceeded by the tegmina. The last sternite of the male is very characteristic, being greatly enlarged and usually swollen. The male plates are very diverse in form, sometimes coalesced at base, and this portion may be greatly enlarged.

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[1] Baker, C. F., Philip. Journ. Sci. § D 9 (1914) 409.

[2] Nothing like thorough collecting has yet been done on Maquiling and Banahao.

[3] Termes. Fuz. (1902) 354.

There is usually marked sexual dimorphism in the form of the head, and may be in coloration as well, in certain species. The heads of males are a little shorter and the apical margin is more broadly arcuate. The color change in the sexes usually consists of reds and yellows being replaced by black, the former markings being occasionally reduced or obliterated in the male. In some species, such as *speciosa* and *colorata,* the colors of males and females may be practically identical. In most of the species, pale yellow markings may vary to reddish or vice versa. In all of the species the two basal joints of antennæ are pale yellow in color.

In *M. tettigonoides* the rostrum is densely clothed with long, stiff, appressed, yellowish hairs. In *M. speciosa* these hairs are long, but far fewer in number. In all the other species they are short and inconspicuous.

The hind tibiæ are armed with three rows of numerous very stout spines of medium length and one row of stout bristles. The fore femora have a short longitudinal row of small erect bristles on distal half beneath. The fore tibiæ have a single row of spines beneath extending the entire length.

Synopsis of the species of Makilingia.

- a^1. Clypeus basally strongly umbonate; very large robust species (7.5 to 10 millimeters) with broad, short heads; front shagreened.
  - b^1. Greenish yellow, with black markings on vertex and pronotum. **M. tettigonoides sp. nov.**
  - b^2. Black, with reddish markings beneath and on fore margin of vertex and tegmina of two shades of reddish beyond the black basal fourth .... **M. speciosa sp. nov.**
- a^2. Clypeus basally gently convex or very slightly raised; small slender species with heads usually longer for the total width.
  - b^1. Front shagreened, sometimes also with small separated punctures.
    - c^1. Front uniformly shagreened, without punctures.
      - d^1. Vertex always more or less punctured and wrinkled.
        - e^1. Tegmina bronzy or greenish fading to brownish; lateral margins of head broadly red, ivorylike callose, as is also basal border of clavus; length 5 to 5.5 millimeters. **M. colorata Baker.**

*e*². Tegmina black, with reddish or yellowish markings or with none; sometimes with pale costal spots; markings of vertex not shining callose.

*f*¹. Tegmina reddish or yellowish marked, at least a narrow commissural line.

*g*¹. Lateral spots of vertex small and distant from eyes, or absent.

*h*¹. Pronotum without distinct transverse rugæ; punctures on base of tegmina smaller, more separated, and with smooth interspaces; costal area subapically with a pale macula; emargination of female genital sternite with a median tooth.

*i*¹. Commissural yellow macula occupying a large part of clavus; spots on vertex four and reddish.
M. maculata Baker.

*i*². Commissural mark reduced to a narrow marginal line; spots on vertex two, large, yellowish.
M. sibuyanensis sp. nov.

*h*². Pronotum with distinct transverse rugæ; punctures on base of tegmina large, crowded, with raised margins between; costal area subapically without pale macula, emargination of female genital sternite evenly arcuate; commissural macula narrower than in *maculata*, sometimes with a yellow dash exterior to it, and in males may be reduced to a slender commissural line .... **M. variabilis sp. nov.**

*g*². Lateral spots of vertex very large, adjoining eyes, and occupying a large part or all of lateral margins of vertex.

*h*¹. Clavus entirely bordered with reddish.

*i*¹. Disk of clavus with two small reddish dots or these coalesced to form an oblique crossband.
M. banahaoensis sp. nov.

*i*². Disk of clavus immaculate........ **M. haightiana sp. nov.**

*h*². Clavus not reddish bordered.

*i*¹. Clavus pale yellowish with two dark discal stripes; eye above entirely yellow bordered.
M. lineata sp. nov.

*i*². Clavus black, with a slender yellowish commissural line; postocular area black.. **M. surigaoensis sp. nov.**

*f*². Tegmina entirely black, except for decolored costal areas; lateral spots of vertex very large but not adjoining eyes.

*g*¹. Tegmina with decolored costal border; front with basal border yellowish; tegminal punctures shallow and well separated; emargination of female genital sternite with a median tooth.................................... **M. panayensis sp. nov.**

*g*². Tegmina without decolored costal border; entire front yellowish; tegminal punctures coarse and crowded; emargination of female genital sternite evenly arcuate.
M. bimaculata sp. nov.

d^2. Vertex almost entirely smooth, without punctures or wrinkles; ocelli nearer to each other than to eyes.
  e^1. Small (length, 5 to 5.5 millimeters); white or pale yellowish throughout .... **M. pallida Baker.**
  e^2. Larger (length, 6.5 millimeters); black, with yellowish legs, genitalia, front, and marks on vertex.. **M. woodworthi sp. nov.**
c^2. Front shagreened, but also with small, deep, mostly separated punctures; largely black.
  d^1. Tegmina without pale costal area.
    e^1. Clypeus emarginate at apex; puncturation above very coarse and thick; length 7 millimeters................ **M. pruinosa Baker.**
    e^2. Clypeus with narrowly rounded apex; punctures shallow and well separated; length, 5 to 6 millimeters.... **M. nigra Baker.**
  d^2. Tegmina with a broad, elongate, whitish, translucent costal area on distal half.. **M. costalis sp. nov.**
b^2. Front without shagreening and with large separated punctures but otherwise smooth, shining; female genital segment medially deeply roundly bisinuately emarginate........... **M. frontalis sp. nov.**

Makilingia tettigonoides sp. nov. Plate 1, fig. 1.

Female.—Length, 8 millimeters. Ochraceous to yellowish; abdomen black with pale segmental margins; tegmina, except costal margins greenish to near apical cross veins, the apices slightly smoky; vertex (Plate 1, fig. 1, *a*) with four black spots, two marginal near apex, and two surrounding ocelli; on infero-posterior surfaces of eyes, beneath posterior margin of vertex and entirely hidden from view without separating the head from pronotum, are two black spots; pronotum with two black spots just behind eyes; large black spots also occur on basal angles of scutellum; basal lateral angles of front narrowly black.

Front strongly convex, medially shallowly depressed, very faintly shagreened, smooth, shining. Clypeus strongly roundly umbonate basally, with surface like that of front. Genæ and loræ with shallow separated punctures. Vertex strongly depressed before the sharp anterior margin, as usual in this genus, the remainder of surface separated into three portions by low rounded longitudinal prominences along the lines of the ocelli, the lateral concavities much the deeper; the median area minutely and sparsely punctured, the lateral areas wrinkled next eyes. Ocelli large, equidistant from basal and antero-lateral margins of vertex and nearer to eyes than to each other. Pronotum uniformly covered with separated punctures, the interspaces smooth, and transverse rugæ not evident. Tegminal punctures well separated, the interspaces smooth. Genital segment apically broadly, deeply, arcuately emarginate.

Male.—Length, 7.5 millimeters. Vertex more broadly rounded apically. Color inclining to testaceous (as is sometimes the case in females). Meso- and metasternal sclerites black. Spots of vertex enlarged and variously coalesced. A common type is represented in males from Baguio (Plate 1, fig. 1, *c*) though many minor variations of this occur. A male color form from Dapitan (Plate 1, fig. 1, *d*) shows complete coalescence of the black spots across disk of vertex. Females occasionally have the male type of marking, and one Baguio female is selected (Plate 1, fig. 1, *b*) which is very similar to Dapitan males. The vertex is finely wrinkled anteriorly also, and has two small deep depressions near basal margin. Genital segment as long as broad, roundly swollen, shining black, hind margin nearly truncate except for a short, acute, median projection; base of the long slender plates very broad, undivided, and swollen.

LUZON, Benguet Province, Baguio and Pauai (Haight's place): Nueva Vizcaya Province, Imugan. MINDANAO, Zamboanga Province, Dapitan (*Baker*).

Makilingia speciosa sp. nov. Plate 1, fig. 2.

Female.—Length, 10 millimeters. Black, venter, femora, and tarsi reddish, tibiæ piceous; lateral margins of cheeks, anterior margin of vertex and narrow posterior border of pronotum yellowish; basal fourth of tegmina and costal margin black, this followed by a broad reddish crossband, remainder pale brown.

Front and clypeus formed as in *M. tettigonoides*, but surface strongly granulate shagreened. Genæ, in the deep concavity, with shallow separated punctures, but none on the yellow border; below and on loræ becoming coarser and with a few rugæ. Vertex (Plate 1, fig. 2, *a*) with median area a little elevated, with coarser, very sparse punctures, and with a deep, subtriangular depression at apex; ocelli large, a little nearer to basal than to antero-lateral margins and nearer to eyes than to each other. Pronotum and scutellum (Plate 1, fig. 2, *b*) as in *M. tettigonoides*. Tegminal punctures much coarser. Genital segment (Plate 1, fig. 2, *e*) medially cross-striate, medially and posteriorly black, the hind margin evenly arcuately emarginate.

Male.—Length, 9 millimeters. Colored like the female. Genitalia (Plate 1, fig. 2, *d*) of remarkable structure, the stout plates arising from a solid base which is extended to one and a half times the length of genital segment. The latter, while characteristically swollen, is comparatively small, with hind margin medially acutely extended.

LUZON, Benguet Subprovince, Baguio (*Baker*). The most conspicuous species of the genus, but apparently rare, only four specimens having been taken.

Makilingia colorata Baker.

Described from Mount Maquiling. We now have specimens of this beautiful and very distinct species from Malinao, Tayabas Province, Luzon; from the Cuernos Mountains of Negros; and from Butuan, Agusan Province, and Surigao, Surigao Province, in Mindanao.

Makilingia maculata Baker.

Originally described from Mount Banahao and Mount Maquiling, this species has since been taken in Malinao, Tayabas Province, Luzon; in Surigao, Surigao Province, and Zamboanga, Mindanao; and in Basilan and Sibuyan Islands.

Makilingia sibuyanensis sp. nov. Plate 1, fig. 3.

Male.—Length, 5.5 millimeters. Black; four marginal spots on vertex and upper border of front (Plate 1, fig. 3, *a*), legs, last ventral segment, and a slender line on claval commissure pale yellow. With a subapical pale spot on costal margin of tegmina, as in *maculata.*

Front, with clypeus, thickly granulate shagreened throughout; clypeus slightly raised basally, but not umbonate as in *M. tettigonoides,* though its outlines are similar to that of the latter species. Genæ and loræ with shallow separated punctures. Vertex with median area gently convex and very sparsely punctate, the lateral depressions nearly smooth except for very strong and irregular wrinkles in postero-lateral corners. Ocelli very large, equidistant from basal and antero-lateral margins, but farther in front of anterior line of eyes than usual and but very little farther from each other than from eyes. Pronotum uniformly covered with large separated punctures, the interspaces smooth and with no indication of transverse rugæ. Genitalia (Plate 1, fig. 3, *b*) of ordinary type.

Female.—Length, 5.75 millimeters. Similar to *maculata,* the large median macula on clavus being of quite the same form as may occur in *maculata.* Vertex with four marginal spots. as in the male; the apical spots in both sexes are larger than the lateral, not smaller as in *maculata.* Genital segment black medially; hind margin with a shallow subrectangular median emargination.

SIBUYAN (*Baker*). It is interesting that *maculata*, found in Luzon and Mindanao, should be replaced in an intermediate island by a very similar but entirely distinct species. Sibuyan is rich in endemic species of many groups, though many species of Sibuyan are also found in Romblon and northern Panay, and this one, also, may occur there.

Makilingia variabilis sp. nov. Plate 1, figs. 4 and 5.

Black; yellow markings in certain forms very similar to those of *maculata*, but very variable and with striking sexual dimorphism. In the fully colored female forms, in addition to the large common claval macula, there is a small separated spot or dash near the middle of clavus and on the adjoining border of the corium; when these lateral spots are lacking, then the median mácula is narrower than in *maculata;* associated with females so marked are males which have the median macula a little narrower but also possess the lateral spot. At times series of females (var. *simillima*) may be taken, all of which have a much narrowed median macula on clavus, lack the lateral spots on corium inner border, and usually lack the apical spots of vertex (Plate 1, fig. 5, *a*); associated with these are males in which the median macula is reduced to a slender commissural line (as also in occasional females) and the spots of vertex (Plate 1, fig. 5, *b*) are entirely lacking. The tegmina have no subapical pale costal spot, but midway, next costal margin, may occur a small waxy pruinose area, though this is usually rubbed off.

Female.—Length, 5.25 millimeters. Front evenly convex, the clypeus slightly raised at base, both thickly granulate shagreened. Genæ and loræ sparsely coarsely punctate. Vertex, behind sharp fore margin, evenly depressed from eye to eye, the median basal area evenly gently convex, and sparsely small punctured; surface next eye and somewhat along fore border wrinkled, the wrinkles much stronger in posterior lateral corners. Ocelli very large, equidistant from basal and antero-lateral margins, and a little farther from each other than from eyes. Pronotum uniformly covered with shallow separated punctures and basally with distinct indications of transverse rugæ. Tegminal punctures well separated, with smooth interspaces. Genital segment broadly, shallowly, arcuately emarginate behind.

Male.—Length, 4.75 millimeters. Genital segment brown, much longer than broad, rapidly broadening caudad, the hind margin with an obtuse median projection which is yellow. Plates as long as genital segment, blunt tipped and testaceous in color.

LUZON, Benguet Subprovince, Baguio and Pauai (Haight's place): Nueva Vizcaya Province, Imugan. MINDANAO, Zamboanga Province, Dapitan. The fully colored typical form and the var. *simillima* occur together in all localities. It would have been difficult to understand this variable species without large series. The genitalia are uniform throughout.

Makilingia banahaoensis sp. nov. Plate 2, figs. 6 and 7.

Black; legs yellowish; head with two small reddish apical spots (Plate 2, fig. 6, *a*) and two very large lateral spots, the latter adjoining eyes; in the var. *montalbanensis*, the subapical spots are coalesced in one large apical spot. Clavus apparently broadly bordered with reddish, very slenderly on median portion of commissure, broader at apex of clavus, the outer reddish stripe being actually located on the corium, along the claval suture; disk of clavus with two reddish dots obliquely placed, and these, in the var. *montalbanensis* (Plate 2, fig. 7, *a*), are coalesced into an oblique stripe, this with the basal and apical reddish borders being much broader than in the typical form. Abdomen with narrowly pale segmental margins.

Female.—Length, 5.25 millimeters. Front gently convex, the clypeus not raised basally, both thickly evenly granulate shagreened; genæ and loræ rather thickly and coarsely punctate. Vertex but little depressed anteriorly and laterally, more strongly so near eyes and medially just before apex; median area very gently convex and more strongly and thickly punctured than in *maculata* and allies. Ocelli of medium size, equidistant from basal and antero-lateral margins, and about as near eyes as to each other. Pronotum with shallow separated punctures and with distinct indications of numerous transverse rugæ. Tegminal punctures well separated and with smooth interspaces. Genital segment broadly deeply marginate, this emargination with a second median subrectangular emargination.

Male.—Length, 4.25 millimeters. Color markings as in female. Genital segment subtriangular, the broad apex nearly equaling length and nearly truncate, without median extension. Plates together forming a long acute triangle, longer than genital segment.

LUZON, Laguna Province, Mount Banahao. The more heavily marked var. *montalbanensis* is from Montalban, Rizal Province.

Makilingia haightiana sp. nov. Plate 2, fig. 8.

Similar to *M. banahaoensis*. Black, legs pale yellow; vertex (Plate 2, fig. 8, *a*) with two very large reddish lateral spots extending from eyes to two-thirds of lateral margins, and a transverse apical spot which is very rarely divided into two, and which is, in the male, completely coalesced with lateral spots forming a continuous red border to vertex except for small black spots left on lateral margin at one-third before apex. Cheeks broadly pale yellow bordered in the female; face entirely yellow in the male. Clavus bordered with reddish yellow, but stripes along suture and commissure very narrow, the apex of clavus not filled with color, and no discal markings. Entire apical area of tegmina subhyaline, with narrow dark apical margin.

Female.—Length, 6 millimeters. Front and clypeus as in *M. banahaoensis;* genæ and loræ shallowly and sparsely punctured. Vertex with shallow lateral depression, the entire median area from between ocelli forward strongly concave; median area strongly thickly punctured, entire basal area strongly wrinkled, some sharp and prominent curved wrinkles passing from outer margins of ocelli to basal margin. Ocelli large, nearly equidistant from basal margin, antero-lateral margins, eyes, and each other. Pronotum with separated punctures and strongly, thickly, transversely rugose over nearly entire surface. Tegminal punctures in great part larger and more thickly placed than usual, especially near claval suture. Genital segment subtruncate posteriorly.

Male.—Length, 5 to 5.5 millimeters. Sharply distinguished by the completely yellow face. Genital segment very large and swollen, oblong elliptical, half again as long as broad, as broad basally as apically, brown, and cross-striate, the apical margin broadly arcuate. Plates very small, obtuse apically, coalesced for almost entire length, and scarcely half length of genital segment.

LUZON, Benguet Subprovince, Pauai (Haight's place) 2,400 meters altitude (*Baker*).

Makilingia lineata sp. nov. Plate 2, fig. 9.

Female.—Length, 6 millimeters. Black; face and legs ochraceous; vertex (Plate 2, fig. 9, *a*) with broad lateral borders reddish yellow from eyes to apex, the inner margins of these marks sinuate, and extending to behind the eyes. Tegmina dark smoky, the broad costal border from basal third, and entire apical area subhyaline; clavi broadly yellowish white, leaving between these areas and the sutures two longitudinal smoky stripes. Abdomen yellowish white, pygofers and disks of tergites darker.

Similar in appearance to the male of *M. haightiana* but distinct in the following diagnostic characters: Front and clypeus far more finely shagreened. Ocelli a little nearer to both basal and antero-lateral margins than to each other, and nearer to each other than to eyes. Genital segment broadly subrectangularly emarginate behind, the emargination with a broad median tooth.

LUZON, Nueva Vizcaya Province, Imugan (*Baker*).

Makilingia surigaoensis sp. nov. Plate 2, fig. 10.

Black; legs ochraceous; vertex (Plate 2, fig. 10) with two elongate yellowish spots extending from eyes to near apex, the inner margins of which are sinuate. Clavus with a very fine commissural yellowish line. Segmental margins of abdomen pale.

Female.—Length, 5 millimeters. Front and clypeus finely granulate shagreened. Genæ and loræ rugose-punctate. Vertex gently evenly concave anteriorly, deeply depressed between ocellus and eye, basal border laterally rather strongly wrinkled; median area with small sparse punctures. Ocelli slightly nearer to basal and antero-lateral margins than to each other, nearer to each other than to eyes, and remarkable in being little less distant from anterior than from basal margins. Pronotum with well-separated shallow punctures and without transverse rugæ. Tegminal punctures shallow, sparse, and inconspicuous. Genital segment with a broad subrectangular emargination, this having a large median tooth.

Male.—Length, 4.5 millimeters. With identical color markings. Genital segment yellow, large, subcircular, swollen, constricted before apex, the broadly rounded hind margin strongly reflexed. Plates black, shining, forming together an acute triangle about as long as genital segment, the acuminate tips strongly curved dorsad.

MINDANAO, Surigao (*Baker*).

Makilingia panayensis sp. nov. Plate 2, fig. 11.

Female.—Length, 5.25 millimeters. Black; legs, upper border of face, two small apical and two large lateral spots on vertex (Plate 2, fig. 11) pale yellowish; narrow costal border from middle of tegmina decolored, this extended more broadly around apex to claval angle. Body above, in fresh specimens, with bluish white waxy pruinosity.

Front and clypeus thickly granulate shagreened. Genæ and loræ rather thickly, coarsely punctate. Vertex large, nearly as long as pronotum, evenly depressed back of sharp fore margin, from eye to eye; median area broadly convex and sparsely minutely punctured. Ocelli nearer to basal than to antero-lateral margins, and a little farther from each other than from eyes. Pronotum with coarse separated punctures and thickly transversely rugose. Tegminal punctures well separated, the interspaces smooth. Genital segment with a broad subrectangular emargination behind, this having a broad median tooth.

PANAY, Capiz Province, Navas (*Baker*).

Makilingia bimaculata sp. nov. Plate 2, fig. 12.

Black, shining; legs ochraceous; front, basal half of clypeus (all of the clypeus in the male), and two large lateral spots on vertex, yellowish (Plate 2, fig. 12, *a*).

Female.—Length, 7.5 millimeters. Front and clypeus very minutely granulate shagreened; lateral borders of clypeus nearly straight, anterior margins laterally reflexed. Genæ and loræ coarsely rugose-punctate. Vertex, in addition to the usual depressions, with a deep subrectangular median excavation reaching from apex halfway to ocellar line, the interior of this being finely longitudinally wrinkled; the median area is a little depressed along median line, convex either side to ocelli, the surface with coarse irregularly separated punctures. Ocelli large, nearer to basal than to antero-lateral margins and equidistant from eyes and from each other. Pronotum with coarse separated punctures and numerous, not sharply marked, transverse rugæ. Tegminal punctures coarse and crowded and extending beyond middle of tegmina. Genital segment (Plate 2, fig. 12, *c*) evenly arcuately emarginate behind.

Male.—Length, 5.5 to 6 millimeters. Genitalia similar to those of *M. surigaoensis* but the reflexed hind border of genital segment is very broad and whitish in color, the plates being testaceous (Plate 2, fig. 12, *b*).

LUZON, Benguet Subprovince, Baguio: Nueva Vizcaya Province, Imugan. MINDANAO, Zamboanga Province, Dapitan (*Baker*).

Makilingia pallida Baker.

Described originally only from Mount Maquiling, this species has also been taken at Malinao, Tayabas Province. A distinct variety (var. *benguetensis*), having an arcuate smoky line passing from tip of clavus to costal margin, has been collected at Baguio, Benguet Subprovince.

Makilingia woodworthi sp. nov. Plate 2, fig. 13.

Male.—Length, 6.5 millimeters. Black; legs ochraceous; front, basal portion of clypeus, borders of genæ, and two very large lateral spots on vertex (Plate 2, fig. 13, *a*) reaching to ocelli, yellow. Tegmina with a pale spot just beyond tip of clavus, and another larger one opposite to it on the costal border, the apical border decolored. Borders of abdominal segments yellowish.

Front and clypeus very finely granulate shagreened. Genæ and loræ coarsely rugose-punctate. Vertex with whole surface, except basal border, deeply evenly concave, the sharp anterior margin more strongly reflexed than in other known species; surface smooth, opaque, practically without punctures or wrinkles. Ocelli large, much nearer to basal than to anterolateral margins and equidistant from each other and from eyes. Pronotum with large separated punctures and strongly, thickly, transversely rugose. Tegminal punctures large, thick set and extending to middle of tegmina (Plate 2, fig. 13, *b*). Plates large, together forming an acute triangle as long as the very broad genital segment, the latter being as broad apically as long, strongly swollen basally, the apical margin broadly arcuate.

LUZON, Laguna Province, Mount Maquiling (*Baker*). This very stout and well-marked species is named for Prof. H. E. Woodworth, who spent two very profitable years of entomological work at the foot of Mount Maquiling.

Makilingia pruinosa Baker.

This species was originally described from Mount Maquiling. It has since been taken on Mount Banahao, Laguna Province; at Baguio, Mountain Province; at Imugan, Nueva Vizcaya Province; and at Dapitan, Zamboanga Province, Mindanao.

Makilingia nigra Baker.

This species was originally described from Mount Banahao. It has since been taken on Mount Maquiling, Laguna Province; in the Cuernos Mountains of Negros; in northwestern Panay;

in Surigao, Surigao Province, Mindanao; and in Basilan. The punctures of front are much more crowded along the median line basally, in the female.

Makilingia costalis sp. nov. Plate 2, fig. 14.

Male.—Length, 5.5 millimeters. Velvety black; legs pale yellowish; tegmina black at extreme base, remainder dark smoky, an elongate whitish translucent costal area extending from basal third to apical cross veins, occupying entire area of subcostal cell.

Front finely shagreened and with numerous small deep punctures scattered sparsely over its surface; clypeus with punctures only at sides. Genæ and loræ with large scattered punctures. Vertex (Plate 2, fig. 14) nearly uniformly deeply depressed over entire surface, the median area with sparse minute punctures, the lateral areas with larger punctures and irregular wrinkles. Ocelli large, equidistant from basal and antero-lateral margins, and farther from each other than from eyes. Pronotum with shallow separated punctures but no indication of transverse rugæ. Tegminal punctures well separated and extending to one-third the length of tegmina.

MINDANAO, Surigao Province, Surigao (*Baker*).

Makilingia frontalis sp. nov. Plate 2, fig. 15.

Black, shining; covered with bluish white waxy powder when fresh; legs and abdomen (except for a spot on genital segment) ochraceous. Tegmina with the subcostal cell whitish translucent from basal fourth to apical three-fourths of tegmina, this area widest at middle.

Female.—Length, 6 millimeters. Head large and subtriangular; front and clypeus (except a small median basal granulate shagreened area) without shagreening, but covered with large, deep, separated punctures (like those of vertex and pronotum), the interspaces smooth and shining. Genæ and loræ thickly coarsely punctate. Vertex (Plate 2, fig. 15, *a*) with median area strongly convexly raised, a narrow and shallow submarginal depression extending around the vertex from eye to eye, the lateral depressions also being shallow; entire surface with large separated punctures; the sharp anterior margin but slightly raised. Ocelli large, a little nearer to antero-lateral than to basal margin, and nearer to eyes than to each other. Pronotum with very large, rather thickset punctures, the interspaces smooth and shining and with no indication of transverse rugæ.

Tegminal punctures close set and extending to two-thirds the length of tegmina. Genital segment with a deep roundly bisinuate median emargination (Plate 2, fig. 15, *b*).

Male.—Length, 5 millimeters. Coloring same as in female. The genitalia are most remarkable. The inflated genital segment, instead of being shortly acute medially, as usual, is here extended caudad in a long stout rapidly narrowing prolongation (Plate 2, fig. 15, *c*). The valves are also remarkable, being spatulate, covered with a dense short silvery pile, the apical margin with a row of short stiffly erect white hairs.

MINDANAO, Davao Province, Davao (*Baker*). This unique species represents as great a departure from the common type in one direction as *M. tettigonoides* does in another.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Makilingia tettigonoides* sp. nov.; *a*, ordinary type of female; *b*, female from Baguio with malelike markings; *c*, male from Baguio; *d*, male from Dapitan.

2. *Makilingia speciosa* sp. nov.; *a*, vertex and pronotum; *b*, head and pronotum, lateral view; *c*, face; *d*, male genitalia; *e*, female genital segment; *f*, tegmen; *g*, wing.

3. *Makilingia sibuyanensis* sp. nov.; *a*, vertex and pronotum; *b*, male genitalia.

4. *Makilingia variabilis* sp. nov., vertex and pronotum; *a*, female; *b*, male.

5. *Makilingia variabilis* var. *simillima* var. nov., vertex and pronotum; *a*, female; *b*, male.

PLATE 2

FIG. 6. *Makilingia banahaoensis* sp. nov.; *a*, vertex and pronotum; *b*, face; *c*, tegmen.

7. *Makilingia banahaoensis* var. *montalbanensis* var. nov.; *a*, vertex and pronotum; *b*, head and thorax, lateral view; *c*, part of tegmen, showing two small interpolated abnormal cells.

8. *Makilingia haightiana* sp. nov., female; *a*, head and pronotum; *b*, upper part of face.

9. *Makilingia lineata* sp. nov.; *a*, vertex and pronotum; *b*, tegmen, apical portion.

10. *Makilingia surigaoensis* sp. nov., vertex and pronotum.

11. *Makilingia panayensis* sp. nov., vertex and pronotum.

12. *Makilingia bimaculata* sp. nov.; *a*, vertex and pronotum; *b*, male genitalia; *c*, female genital segment.

13. *Makilingia woodworthi* sp. nov., male; *a*, vertex and pronotum; *b*, genitalia.

14. *Makilingia costalis* sp. nov., vertex and pronotum.

15. *Makilingia frontalis* sp. nov.; *a*, vertex and pronotum; *b*, female genitalia; *c*, male genitalia.

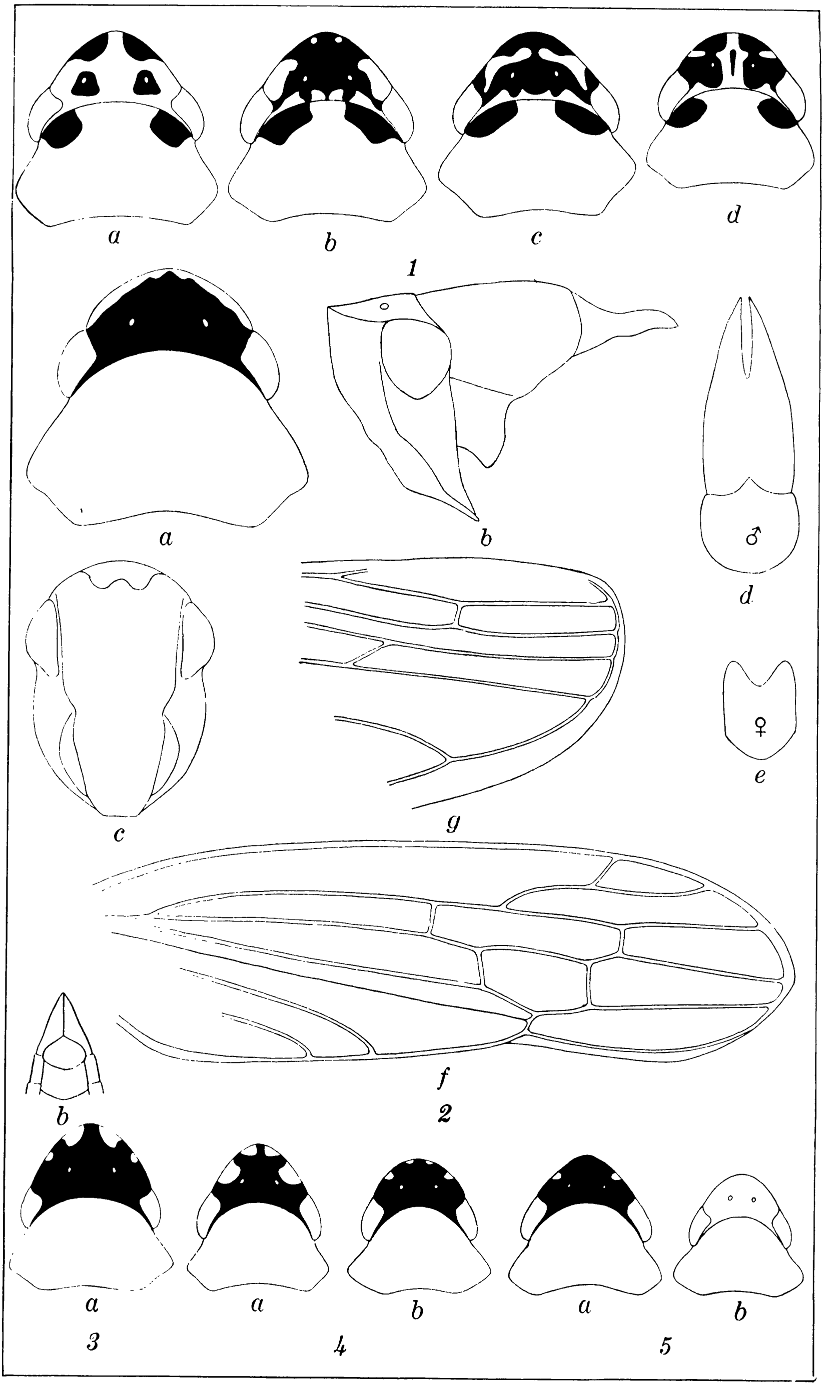

PLATE 1.

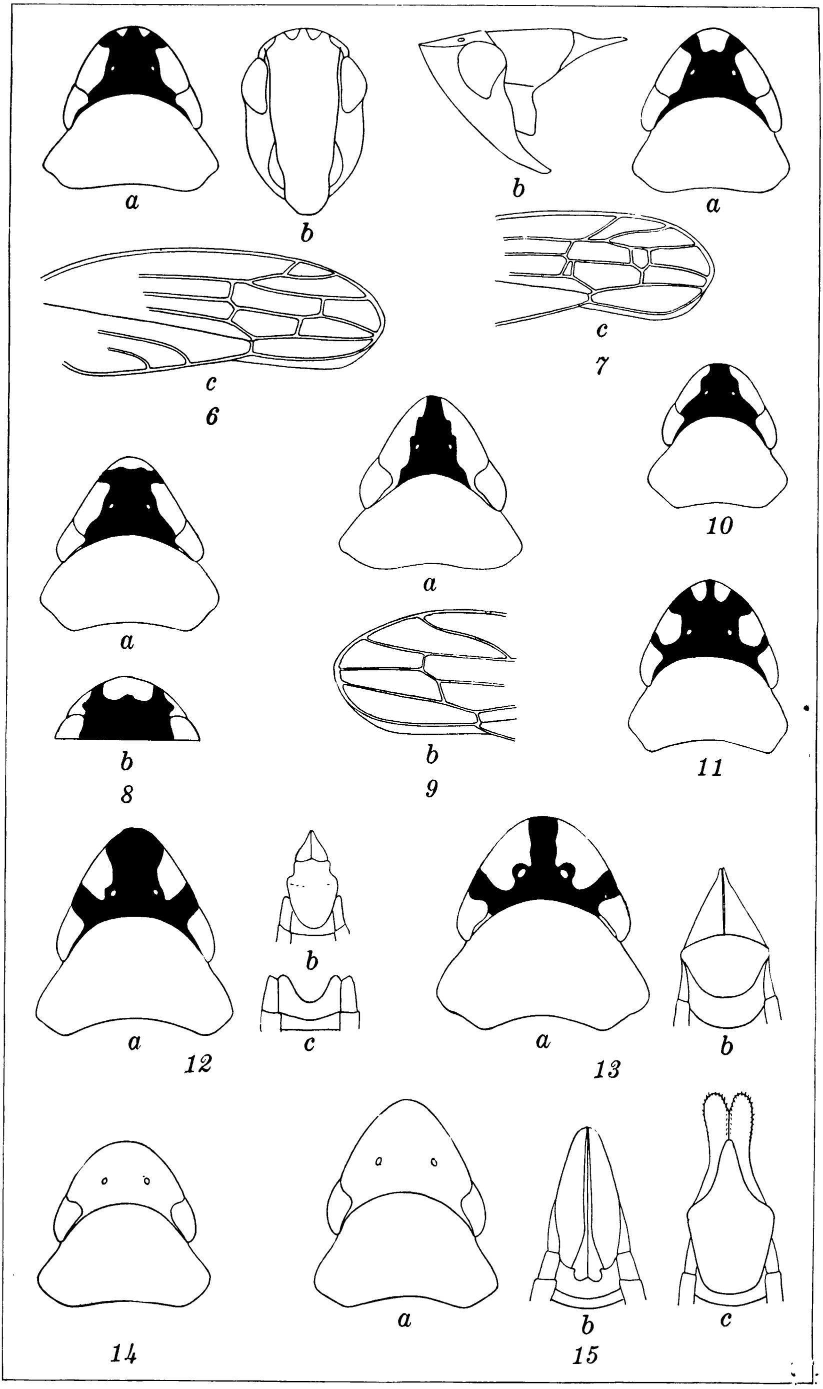

PLATE 2.

TWO DIPTÉRA PUPIPARA FROM PHILIPPINE BATS

By G. F. FERRIS

Of Stanford University, California

THREE TEXT FIGURES

The dipterous parasites of bats included in the two families Streblidæ and Nycteribiidæ are extremely well represented in the East Indian and Malayan regions. In fact, it is here that they seem to attain their greatest abundance, not only in number of species but in number of individuals as well. Yet, curiously enough, there appears to be practically no knowledge of the Philippine representatives of these groups. Indeed, I have been able to find no record of streblids and but one record of a nycteribiid from those islands, the latter being the somewhat dubious record of the occurrence of *Cyclopodia dubia* (Westwood). There are likewise few, if any, records of Hippoboscidæ.

Through the kindness of Dr. C. F. Baker I have been enabled to examine material representing one species of the first two of these families. This paper then may be regarded as the beginning of the study of the Philippine Diptera Pupipara. That a very extensive fauna of the three families Hippoboscidæ, Nycteribiidæ, and Streblidæ contained in the Pupipara will finally be revealed is unquestionable.

STREBLIDÆ

Nycteribosca gigantea Speiser. Figs. 1 and 2.

Nycteribosca gigantea SPEISER, Archiv für Naturgesch. 66[1] (1900) 46, fig. 1.

Previous records.—Known only from the original description, from the Bismarck Archipelago, of *Cephalotes peronii*. The male only has been described.

Present record.—From undetermined bats, Montalban, Rizal Province, Luzon, Philippine Islands. Collected by Edward H. Taylor. Three females and two males.

Female.—(Fig. 1.) Length, 4.5 millimeters. General color reddish brown, except for the head which is almost black with a pale median dorsal stripe and pearly eyes.

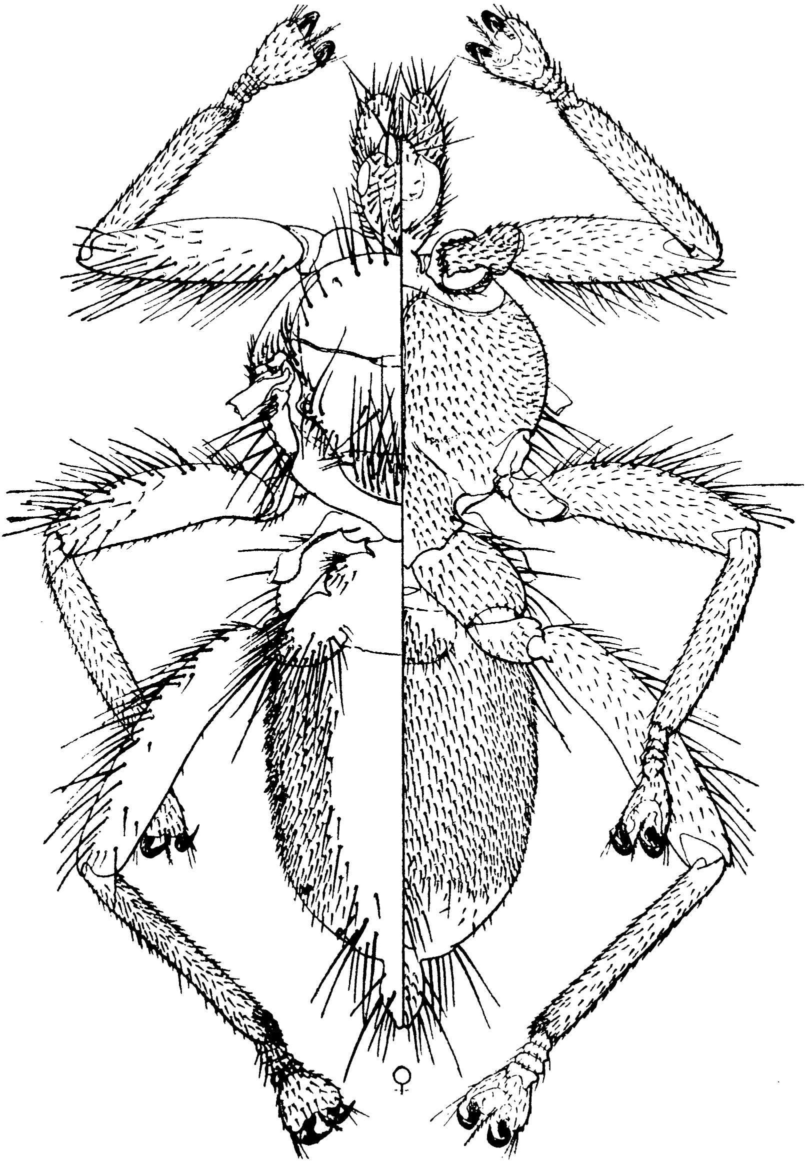

FIG. 1. *Nycteribosca gigantea* Speiser; female, wings removed.

Thorax almost spherical, somewhat flattened dorsally and ventrally. Pronotum with a few long setæ along the lateral margin. Mesonotum likewise with a few long setæ along the lateral margin, scutellum thickly beset with long, stout, upright setæ. Pleuræ, immediately in front of wings, with a few short, stout setæ. Behind base of wings are what are apparently the squamæ, these bearing several long, stout setæ. Ventral side thickly beset with short setæ which are evenly disposed.

Wings (fig. 2, *b*) about as long as the body, the veins rather weak, disposed as indicated in the figure; beset throughout with minute setulæ.

Legs moderately stout, the hind legs only a little longer than the others, the anterior margins of femora with many long setæ, the ventral side of femora and all of the tibiæ thickly beset with small setæ. Tarsi five-segmented, the last segment much enlarged.

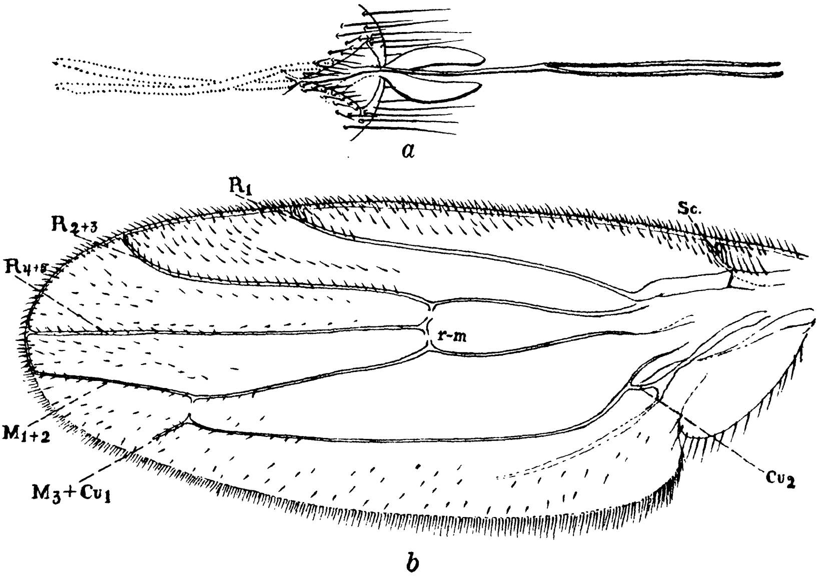

FIG. 2. *Nycteribosca gigantea* Speiser; *a*, genitalia of male; *b*, wing, wing veins labeled according to the Comstock-Needham system.

Abdomen with the basal tergite occupying about a fourth of its length and bearing many long setæ at the apical angles. Remainder of dorsum with numerous short setæ except for a median area occupying about a third or half of its width which is entirely naked. Apex of abdomen produced into a median lobe which bears several long setæ. Ventral side with an indistinct basal plate, this and the remainder of surface except near apex beset with many small setæ. Five pairs of spiracles present, these small.

Male.—Length, 4 millimeters. In general very similar to the female but with apex of abdomen conical, bluntly rounded, and bearing many long setæ. No external claspers; internal genitalia (fig. 2, *a*) represented by two long, slender basal apodemes which articulate with a very slender apical piece of somewhat greater length that is divided into two slender forks. There are also two small flaplike pieces, which appear to articulate with a basal apodeme but are separate from the slender rods described.

According to Speiser this is the largest of the streblids. It has been known only from the male, and I am presenting a description and figures of the female and some further notes on the male.

NYCTERIBIIDÆ

Eucampsipoda philippinensis sp. nov. Fig. 3.

Specimens examined.—Two females and three males, from undetermined bat, Montalban, Rizal Province, Luzon, Philippine Islands. Collected by Edward H. Taylor. Holotype, a female, and allotype in the Stanford University collection, paratypes returned to Doctor Baker.

Female.—(Fig. 3, *a.*) Length, 2 millimeters. A rather small, pale-colored species.

Head slender and strongly arched, destitute of setæ dorsally except for three or four along anterior border; ventral side with a few small setæ; palpi long and slender, bearing four or five long setæ near tip. Eyes very small, consisting of a single facet.

Thorax very slightly longer than wide, forming nearly an equilateral triangle. Dorsal side destitute of setæ except for a single stout seta near each haltere. Ventral side rather sparingly beset with small setæ. Thoracic ctenidia very prominent.

Legs (fig. 3, *b*) rather short, the tibia with two transverse rings, the dorsal side of tibia and femur with numerous setæ of varying lengths, the ventral side nearly bare.

Abdomen almost completely membranous except for the basal tergite and sternite, a pair of weak subapical ventral plates, and the apical lobe. Basal tergite with numerous small and a few long setæ along margin. Remainder of dorsum thickly beset with small setæ and with an irregular cluster of long setæ in the median region. Apical lobe with several long setæ. Basal sternite with numerous small setæ on distal half and with about thirty-two setæ in the ctenidium. Chitinized plates near apex of abdomen bearing three or four long setæ, remainder of venter beset with small setæ mingled with a few that are conspicuously larger.

Male.—Length, 2 millimeters. Head and thorax as in the female.

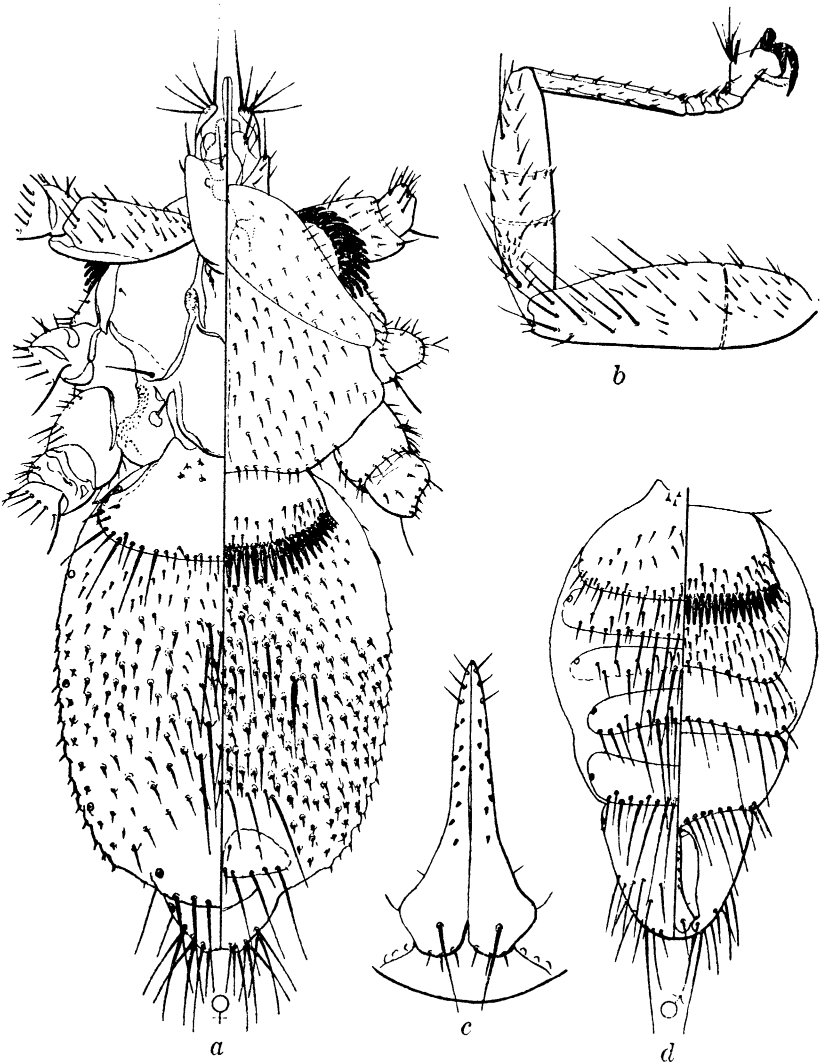

FIG. 3. *Eucampsipoda philippinensis* sp. nov.; *a*, female, legs removed; *b*, dorsal aspect of front leg; *c*, claspers of male; *d*, abdomen of male.

Abdomen (fig. 3, *d*) with the tergal and sternal plates rather weakly chitinized. Basal tergite with a few small setæ on disk and along margin. Second tergite extending nearly across abdomen, but short, bearing a few short setæ on disk and several setæ of variable lengths along margin. Third tergite narrower than second, but about as long, fourth still narrower, fifth somewhat broader, all these with long setæ along posterior margin. Terminal segment about a fourth as long as abdomen, broad, bluntly rounded at tip, and bearing numerous long setæ on apical half.

First sternite as in the female. Second nearly as long as first, bearing numerous small setæ on disk and longer setæ on margin. Third shorter than second, with long setæ on margin. Fourth as long as first, somewhat produced medially and with numerous setæ of varying lengths along posterior margin.

Claspers (fig. 3, *c*) slender, closely approximate, destitute of slender setæ except for three near apex, bearing a number of short, black, tuberclelike setæ.

Two species have heretofore been described in this genus. Of these, *Eucampsipoda aegyptia* (Macquart) has been recorded only from Egypt and is so inadequately described that it is scarcely recognizable. The other, *Eucampsipoda hyrtli* (Kolenati), has been recorded from Egypt, Senegal, Sumatra, Burma, Ceylon, and the Comoro Islands. I have at hand specimens from Ceylon. *Eucampsipoda philippinensis* is easily separable from this, in the female by the absence of the two groups of extraordinarily heavy setæ on the dorsum of the abdomen, and in the male by the presence of the small, black tubercles on the claspers. In the male of *hyrtli* these tubercles are entirely lacking and the claspers are fringed with small setæ of varying lengths.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Nycteribosca gigantea* Speiser; female, wings removed.

2. *Nycteribosca gigantea* Speiser; *a*, genitalia of male; *b*, wing, wing veins labeled according to the Comstock-Needham system.

3. *Eucampsipoda philippinensis* sp. nov.; *a*, female, legs removed; *b*, dorsal aspect of front leg; *c*, claspers of male; *d*, abdomen of male.

GYRINIDÆ OF THE PHILIPPINE ISLANDS

By Georg Ochs

Frankfurt am Main, Germany

Through the kindness of Mr. W. Schultze, entomologist of the Bureau of Science, Manila, I received for determination the Gyrinidæ in the collection of that institution. I wish to thank Prof. C. F. Baker, of Los Baños, for placing at my disposal the material of his collection. Almost at the same time the well-known firm Dr. O. Staudinger and A. Bang-Haas, Dresden-Blasewitz, sent to me for examination a large amount of material of Gyrinidæ from the Philippine Islands. Among the material were two new species, which will be described herein. It is very remarkable that the largest and most-beautiful species of the genus *Orectochilus* from the Philippine Islands should come to our knowledge only now, and I suppose that in collecting systematically additional new species of Gyrinidæ will be discovered in that country, especially of the genus *Orectochilus*, as these Coleoptera often have a very local distribution.

All Gyrinidæ of the Philippine Islands known so far have been enumerated[1] with the exception of the two new species mentioned above. I propose to give in the following a recapitulation, adding thereto the remarks resulting from my last studies, also giving the chief characters of the different species, which will enable collectors to distinguish and to determine them.

Key to the known genera and species of Philippine Gyrinidæ.

a^1. The upper surface of insect without hairs.

  b^1. About 6 millimeters long or longer, scutellum invisible........ **Dineutes.**

    c^1. Length, 6.5 to 9 millimeters; flatly vaulted, attenuated to both ends, metallic dark below; elytra of male terminated exteriorly before the truncature with a small spine, of female straightly truncated.. **D. australis F.**

Luzon, Manila, several specimens in my collection (*v. Möllendorf, Koechlin, Boettcher*): Nueva Vizcaya Province, Imugan, 48 males and 83 females: Zambales Province: Laguna Province, Paete: Mountain Province, Butac, a series in some of which there is a greater number of males and in others the number of females is greater (*Staudinger*); Sablan (*Schultze*); Baguio (*Baker*). NORTHWESTERN PANAY (*Baker*). MINDANAO, Zamboanga (*E. Dexter Allen*).

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[1] Schultze, W., A Catalogue on Philippine Coleoptera, Bur. Sci. Spe. Publ. 7 (1915) 20.

This very common species is widely distributed and occurs also in Formosa, Sunda Islands, Malacca, Australia, New Zealand, and New Caledonia.

There is a variety of this species that is totally opaque reddish brown. In some males the apical spine of the elytra is reduced to a little sharp corner, especially among specimens from northwestern Panay, which moreover are remarkable by their very small size.

*c*². Length 6 to 7.5 millimeters; in general smaller than the preceding, less flattened, attenuated chiefly to the fore part, red-yellow below, spines at exterior angles of elytra more prominent. **D. curtulus Rég.**

LUZON, Nueva Vizcaya Province, Imugan, 1 male: Bataan Province, Zambales, 3 males and 16 females (*Staudinger*).

Régimbart described this species from a single male from Manila. Staudinger's material contained several females, the first known; these are completely like the male and are distinguished only by the anterior tarsus being much smaller, as is usual in the Gyrinidæ.

While Régimbart compares this species to *Dineutes sharpi* and *D. australis*, I would state that its nearest ally is *D. unidentatus* Aubé, of Ceylon, India, and China. I even doubt that *D. curtulus* should be considered a separate species; it seems, rather, to be only a variety. Perhaps the structure of the penis will help to solve the problem; unfortunately, the material at my disposal was insufficient for such study.

In comparison with *D. unidentatus* the species in question is broader and therefore appears shorter. The apical outline of elytra is very similar, but more prominent, and the median angle of the truncature much sharper, while in *D. unidentatus* it is mostly rather rounded. On the lateral portion of the elytra in *D. unidentatus* there is a very pronounced cavity, which is scarcely noticeable in *D. curtulus*. The sculpture of the elytra is alike in both species, being reticular with isolated punctures and scarcely impressed longitudinal striæ; the anterior tibiæ and tarsi do not present any particular differences, and it is characteristic of both species that the male and the female are alike in form, with the single exception of the anterior tarsus.

*b*². Less than 6 millimeters long, scutellum visible.............................. **Gyrinus.**

*c*¹. Epipleura black, below dark. Length, 3.5 to 4.5 millimeters; short-oval, highly vaulted, the seventh interstice on elytra evidently convex; elytra, especially on the lateral portion, strongly reticulated .... **G. sericeolimbatus Rég.**

LUZON, Mountain Province, Baguio (*Baker*). Also known from Celebes, Java, Sumatra, and New Guinea.

*c*². Epipleura red, below more or less red.

*d*¹. Length, 5 to 6 millimeters, oblong-oval, elytra of male finely punctate, of female more so, the punctures of series small; tip of elytra with rounded angles .... **G. tenuistriatus** Rég.

This species, described by Régimbart from the Philippine Islands, was not represented in my material.

*d*². Length, 5 millimeters, elongate-oval, posteriorly attenuated. Elytra, at least of male, entirely smooth, the punctures of series more impressed; tip of elytra with sharper angles. **G. oceanicus** Rég.

This species was not included in the material received. Known by Régimbart from the Philippine Islands and from Borneo.

*a*². Surface of elytra and of prothorax with hairs on lateral portion. **Orectochilus.**

*b*¹. Prothorax and elytra without a yellow margin. Length, 6.5 to 7.5 millimeters, oval; the smooth part of elytra covers about half the length and is extended into a small point reaching backward about to two-thirds the length of elytra. Exterior apical angle of elytra not pointed .... **O. palawanensis** Rég.

SOUTHERN PALAWAN (*Staudinger*). NORTHERN PALAWAN, Binaluan, November and December, 1913 (*Boettcher*).

*b*². Prothorax and elytra with a yellow margin.

*c*¹. Apical angles of elytra exteriorly without a pronounced spine. Ovate.

*d*¹. The smooth part of the elytra extends backward at the most as far as about two-thirds and is nearly rounded behind. Large species, 7.5 to 8.5 millimeters long, the description of which is given at the end of this paper............... **O. schultzei sp. nov.**

LUZON, Mountain Province, Benguet, Trinidad, types (*C. S. Banks*); Baguio (*Baker*): Nueva Vizcaya Province, Imugan (*Staudinger*).

The material received from Staudinger contained several specimens of a variety which differs from the typical individuals by its smaller size (6.5 to 7 millimeters), being moreover less vaulted in the scutellar region and less convex in the humeral part. The smooth part on the elytra is less regularly rounded behind, but a little heart-shaped with evidently concave sides posteriorly. There is no specific distinction from the typical individuals, but the difference is considerable on first view.................... **O. s. var. minor var. nov.**

LUZON, Mountain Province, Butac (*Staudinger*).

*d*². The smooth part of elytra covers about three-fourths of the length, reaching suture behind in an angle of about 45°; 6.5 to 7 millimeters long, anterior legs small.... **O. oberthüri** Rég.

LUZON, Rizal Province, Montalban (*C. S. Banks*); Montalban (*Staudinger*): Camarines Sur Province, Mount Isarog, 32 specimens (*Staudinger*). Already mentioned by Régimbart from Manila and Mindanao.

Several specimens are remarkable by their small size (only 5.5 to 6 millimeters), but do not differ in any manner from the typical form.

LUZON, Mountain Province, Butac (*Staudinger*).

d^3. The smooth part of the elytra covers about six-sevenths of the length, quite rounded behind; 4 to 4.75 millimeters long. **O. pulchellus** Rég.

LUZON, Nueva Vizcaya Province, Imugan (*Staudinger*): Mountain Province, Butac (*Staudinger*): Laguna Province, Los Baños (*Staudinger*): Rizal Province, Montalban (*Villegas, Staudinger*); Camarines Sur Province, Mount Isarog (*Staudinger*): Nueva Ecija, Santor (*W. Schultze*). MINDANAO, Bukidnon Province, Tangkulan (*W. Schultze, Staudinger*): Surigao (*Baker*): Zamboanga (*T. C. Zschokke*).

Several specimens of this apparently very common species differ by the hairy portion of the elytra which is anteriorly somewhat smaller, the smooth part being consequently somewhat enlarged in this region; but no further distinction is found.

c^2. Apical angles of elytra exteriorly rather prominent, nearly spined.

d^1. The smooth part of elytra covers about three-fourths of the length and is pointed at the end. Elytra sculptured with little oblique striolæ; 5 to 6 millimeters long.. **O. discus** Aubé.

LUZON, Bataan Province, Lamao (*Staudinger*): Nueva Vizcaya Province, Imugan (*Staudinger*): Laguna Province, Paete (*Staudinger*); Mount Maquiling (*Villegas, Baker*); Los Baños (*Staudinger*): Rizal Province, Montalban (*Staudinger, Villegas*): Mountain Province, Butac (*Staudinger*); Irisan (*Schultze*): Camarines Sur Province, Mount Isarog (*Staudinger*). MINDANAO, Bukidnon Province, Tangkulan (*Baker*). NEGROS, Occidental Negros Province (*C. S. Banks*).

The great variableness of this species, as mentioned by Régimbart, was also evident in the material at my disposal. There are differences in shape, which is mostly attenuated to the posterior, but sometimes nearly regularly oval, and moreover in the form of the smooth part on the elytra, the extension of which is subject to considerable variation. The apical angle of the elytra may be more or less spinous, but in all cases the striolæ on the elytra are to be noted.

Some specimens from Paete differ especially by their very short-oval and very convex shape, the smooth part of the elytra being nearly oval behind and reaching rather far to the posterior. There are however no other specific differences, some of the specimens even passing over to the typical form.

The specimens from Mount Maquiling received from Mr. Baker show on the elytra on the lateral hairy portion a number of little tubular formations of about 0.1 millimeter in length, ampliate to the top, somewhat contracted just before the latter. In form they remind one of the *Hydra*, and I should be inclined to suppose them to be related; it remains however to examine the particulars of these formations.

d^2. The smooth part of the elytra reaches backward nearly to sutural angle. Large species, 7 to 8 millimeters in length, the description of which follows below. Attenuated to both ends, elongate, without striolæ on elytra .... **O. bakeri** sp. nov.
MINDANAO, Bukidnon Province, Tangkulan (*Baker*).

c^3. Apical angle of elytra exteriorly with a very pronounced spine; elongate-oval, elytra with oblique striolæ.

d^1. Length, 5.5 to 6 millimeters; the smooth part of the elytra reaches about three-fourths of the length.......... **O. baeri** Rég.
LUZON, Laguna Province (*E. D. Merrill*). Described by Régimbart from specimens from Manila (*Baer*).

d^2. Length, 4.5 to 5 millimeters; very similar to the former and probably its nearest ally. Smaller, dark without the metallic hue of the preceding. The hairs on the lateral portion of elytra are whitish, while in *O. baeri* they are golden.
O. acuductus Rég.
BALABAC (*Staudinger*).

Orectochilus schultzei sp. nov.

Long. 7.5 ad 8.5 mm. (ano excepto), ovatus, convexus, ad humeros inflatus, postice leviter attenuatus. Supra nigro-olivaceus, nitidissimus, in pronoto elytrisque anguste ferrugineo marginatus; subtus nigro-ferrugineus, abdomine pedibusque rufis, epipleuris flavis. Capite subtilissime reticulato, labro transverso, antice modice rotundato, punctato, ciliis flavis brevibus antice longioribus instructo. Pronoto vix visibiliter reticulato, multo latius antice quam postice ad latera punctato-tomentoso. In elytris margine tomentoso ad humeros parum lato, postice latissimo, suturam ad tertiam partem attingente; spatio scutellari laevi, late ovali, postice vix acuminato; truncatura fere recta, angulo externo recto vix prominulo, interno recto. Tibiis anterioribus sat robustis et latis, ad basin breviter attenuatis, fere recte truncatis, angulo externo fere recto; tarso apud ♂ tibia paulo angustiore, apud ♀ multo angustiore.

LUZON, Mountain Province, Benguet, Trinidad, types; 2 males and 2 females in my collection and in the collection of the Bureau of Science, Manila.

Gratefully dedicated to Mr. W. Schultze, Manila.

Orectochilus bakeri sp. nov.

Long. 7 ad 8 mm. (ano excepto), ovatus, elongatus, antice et postice sat attenuatus, valde convexus. Supra niger, nitidissimus, flavo limbatus; infraniger, ano pedibusque natatoribus ferrugatis, epipleuris flavis. Capite magno, antice subtilissime reticulato. Labro fere semicirculari, punctato, ciliis brevibus flavis antice longioribus instructo. Prothoracis margine tomen-

toso parum lato, antice latiore, elytrorum ad humeros eadem latitudine, post humeros diminuato et de unde fere ad suturae apicem oblique et undulatim dilatato; spatio suturali postice evidenter acuminato, apicem versus tenuiter reticulato, in regione scutellari laevi; truncatura leviter obliqua et sinuata, angulo externo acuto, breviter spinoso, interno recto. Tibiis anterioribus rectis sat latis, ad basin attenuatis, postea subparallelis, fere recte truncatis, angulo externo paulatim rotundato; tarso apud ♂ sat lato, ad apicem attenuato, apud ♀ multo angustiore et subparallelo.

MINDANAO, Bukidnon Province, Tangkulan, types (*Baker*); 3 males, 1 female in my collection; further specimens in the collection of Prof. C. F. Baker, to whom I gratefully dedicate this species.

THREE NEW CICINDELIDÆ FROM THE PHILIPPINES

By WALTHER HORN

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Cicindela dilatotarsa sp. nov.

C. spinolai Gestro affinis, differt imprimis ♂ 3 primis tarsorum anticorum articulis cyaneis et multo magis dilatatis (praesertim tertio); elytrorum margine (praesertim pone medium) etiam paullo magis declivi puncto albescente antico discoidali deficiente, macula ante-apicali striolam tenuem postice paullulum incrassatam usque ad angulum suturalem emittente. Postico femorum 4 anteriorum margine pilis longissimis tenuibus ornato. Long. 7 mm. (sine labro).

LUZON bor. (coll. collectione *Ehlers-van de Poll*), 1 ♂.

The only specimen is unfortunately in very bad condition, as the antennæ, middle tarsi, and tibiæ and tarsi of the hind legs are missing. At first view the species reminds one of *C. spinolai,* which shows relatively less prominent eyes, the prothorax a little stouter, and the declivity of the border of the elytra as well as their punctation a little more developed than usual for the species. Labrum, palpi, coloration, and pubescence of body as in the latter. Middle part of metasternum with a fine sparse pilosity. The four anterior femora show a row of very long and very fine bristles on their hind border, whereas in *C. spinolai* these bristles are much shorter on the front femora and quite missing on the middle femora. The difference in the anterior tarsus is very remarkable: the first three parts in the male of *C. spinolai* are long and cylindrical, while they are large and flattened in the new species, the third part being especially broad and flat!

Cicindela microcephala sp. nov.

Ad sectionem VII, 2 (*C. virginea* et *simulatrix*) pertinens; differt ab utraque palpis paullo longioribus magisque tenuibus, capite perparvo, oculis multo minus prominentibus, orbitis subtilius striolatis; prothorace breviore; elytris paullo brevioribus, convexioribus, praesertim apicem versus evidenter declivibus, ad basim ipsam non politis, coeruleis submicantibus, minus velu-

tinis (ut sculptura paullo magis appareat), spina suturali breviore, margine apicali ante spinam suturalem minus angulato-rotundato, plaga ♀ prope suturam in quarta parte antica subnitente. Long. 9 mm. (sine labro).

MINDANAO, Surigao (*C. F. Baker*), 1 ♀.

This species resembles *C. virginea* subsp. *interposita,* but, besides the above-stated differences, differs by the more nearly parallel elytra with the apex more shortly rounded, the naked episterna of the prosternum, etc. The labrum is short and metallic, its medial bristles quite removed from the anterior margin; pronotum naked, very convex, quite smooth; elytra convex and, as regards the posterior declivity and the formation of the apex, resembling *C. clara* Schaum. The first two abdominal ventrites naked, the others laterally with white bristles of medium length and a very fine and minute pilosity on their disks. The hooked hairs on the femora fine but distinct.

Prothyma discrete-punctata sp. nov.

P. hopkinsi affinis, differt tota corporis superficie multo magis splendente ("polita," ut ita discam), capite crassiore, orbitis magis prominentibus, frontis sculptura magis levigata (striis grossis juxta-orbitalibus exceptis), disco fere nigricante, plagis viridibus et cyanescentibus deficientibus. Pronoto aureo-cuprascente politissima, convexiore, paullo longiore, levius sculpto, colorationibus viridi-cyaneis et in sulcis et episterna versus fere totis deficientibus. Elytris purpureo-cupronigricantibus, convexioribus, multo minus dense leviusque sculptis; punctis in dimidia parte antica insculptis, evidenter distantibus, postea hinc inde singulis inter se attingentibus (sed rugis deficientibus): impressionibus 5 ornatis; 1*a* posthumerali, 2*a* ad suturam in quarta parte antica posita, 3*a* ante maculam mediam marginalem, 4*a* (leviore) ad marginem anticum internum maculae apicalis, 5*a* ante apicem collocata; maculis 3 rotundatis albescentibus inter se aequalibus, duabus posticis aequaliter a margine distantibus (fere ut in *P. schultzei*); paullo magis a margine distante quam macula apicali *P. hopkinsi.* Femoribus totis rufo-testaceis. Long. 12 ad 14 mm. (sine labro).

SIBUYAN (*C. F. Baker*), ♀ ♂.

The form of the labrum, palpi, and penis is about the same as in *P. hopkinsi,* from which it differs at first view by the almost "polished" appearance of the whole upper side of the body, where almost all greenish and cyaneous colorations are missing; the head is larger, the eyes are more prominent, and

the prothorax is more convex; front and pronotum with smoother sculpture (excepting the rough juxtaorbital striæ). The elytra are more convex and show five more or less developed impressions and with the punctures much less closely set and less deep, even evidently less deep and less dense than in *P. schultzei,* which species resembles the new species a little in coloration and by the formation of the five impressions of the elytra; but *P. schultzei* has the last impressions much longer and more flattened (especially toward the apex!) and has the whole posterior part of the penis longer and narrower, while the new species has the bulky penis of *P. hopkinsi.* The most remarkable feature of the new species is the sculpture of the anterior half of the elytra, where the single punctures are quite flat and far removed one from the other.

REMARKS ON THE TETTIGOMETRIDÆ (FULGOROIDEA)

By C. F. Baker

Dean, College of Agriculture, University of the Philippines

ONE PLATE

Among the Fulgoroidea no family is more isolated and peculiar than the Tettigometridæ.[1] The strongly jassoid aspect, the entirely unarmed hind tibiæ, the ocelli placed not beneath the eyes but approximate to the inner apical angle of eyes and usually mesad of the inner margin, the highly modified second antennal joint, broad propleuræ, very large tegulæ, with other characters of head, tarsi, tegmina, and apparently also of genitalia, combine to give these insects a most distinctive appearance and character.

A few species live in ant nests. More live on plants in an ordinary way, and some are of economic importance. *Tettigometra* (sens. lat.) is confined to Europe, North Africa, and western and northern Asia. Other genera are distributed through South and Central Africa, and Indo-Malayan regions. Only one of these extra-European genera (*Isthmia* || = *Hilda*) was known at the time of Signoret's review in 1865[2] or of Fieber's review in 1876.[3] The old genus *Tettigometra* Latr. gradually became highly heterogeneous through the addition of very diverse forms. Signoret defined subgenera which may not all represent natural groups, though they appear mostly to represent distinct genera. I am not acquainted with any attempt thoroughly to systematize the group on the basis of the anatomy in general. Certain it is that such species as *brunnea* Sign., *impressifrons* M. R., *longiceps* Sign., and *lucida* Sign., are not congeneric with *obliqua* Panz., the type of the genus *Tettigometra*.

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[1] A complete bibliographic history of the family was given by Horvath, Ann. Mus. Nat. Hung. 9 (1911) 32.

[2] Ann. Soc. Ent. Fr. 6 (1866) 139 et seq.

[3] Rev. Mag. Zool. (1876) 111–153.

In all Tettigometridae known to me the outer basal margins of tegmina are strongly deflexed and retracted beyond the subcostal vein, the actual costal margin at base not being visible from above. There are thus formed very distinct and characteristic epipleuræ which vary in shape in the different species and genera, and which may extend to nearly half the length of the tegmina.

The following synopsis represents merely a tentative review, and indicates clearly the great need of thorough revisional work. It serves to show the general relations of Indo-Malayan forms within the family.

Synopsis of subfamilies of Tettigometridæ.

a^1. Vertex always broader between eyes than long; face medially plane or protuberant; head distinctly narrower than pronotum.
  b^1. Antennal second joint not extending beyond eyes (dorsal view); head but little narrower than pronotum; outer posterior angles of eyes (dorsal view) not touching pronotum, being separated by the thickened posterior margin of vertex which extends (postocular process) more or less beyond eye laterally; face nearly plane (in profile) .... **Tettigometrinæ.**
  b^2. Antennal second joint extending strongly beyond eyes in dorsal view; head conspicuously narrower than pronotum; outer posterior angles of eyes (dorsal view) touching pronotum; face umbonate or more or less angulate at middle (in profile) .... **Egropinæ.**
a^2. Vertex longer than broad between eyes and narrowly acute apically; face medially depressed; head nearly as wide as pronotum. **Megaloplastinxinæ.**

TETTIGOMETRINÆ

Synopsis of genera of the subfamily Tettigometrinæ.[4]

a^1. Postocullar callosities not or very slightly extended laterally beyond eyes; outer margins of tegmina in repose, more or less distinctly converging caudad.
  b^1. Head large, long triangular, its length subequaling half breadth, longer than pronotum, its greatest width about five-sixths that of pronotum; mesonotum far shorter than head and pronotum together; antenniferous tubercles very strongly developed; eyes small, not prominent (fide Signoret) .... **Mitricephalus** Signoret. (Type, *longiceps* Sign.)
  b^2. Head small and subangular anteriorly or broad, short, and broadly arcuate anteriorly; mesonotum always distinctly longer than head and pronotum together.
    c^1. Head subangulate anteriorly between eyes, distinctly longer at middle than eyes, its width not more than three-fourths that of pronotum, usually less; lateral margins of vertex distinctly ex-

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[4] This purely tentative synopsis does not include *Eurychilella* or *Eurychilopterella* of Reuter, the descriptions of which are not available to me.

tended in front of eyes; pronotum distinctly emarginate or incurved at base (fide Signoret)................... **Tettigometra Latreille.**
(Type, *obliqua* Panz.)

c^2. Head broadly and evenly arcuate anteriorly between eyes, length at middle little greater than at eyes, its width about nine-tenths that of pronotum; general form narrowly ovate, the outer tegminal margins broadly outcurved; pronotum subtruncate at base (fide Signoret)................................. **Brachycephalus Signoret.**
(Type, *lucida* Sign.)

a^2. Postocular callosities very strongly developed, extending beyond eyes a distance nearly equaling width of eyes; anteocular margins of vertex bulging beyond outer line of eyes, the eyes thus appearing very deep set (dorsal view); vertex very broadly and evenly arcuate between eyes; fore and hind margins of pronotum subparallel, the basal margin thus strongly incurved; costal borders of tegmina reflexed, the outer margins (in repose) slightly divergent caudad.
Eurychila Signoret.
(Type, *decorata* Sign.)

EGROPINÆ

A study of much Indo-Malayan material in this subfamily has convinced me that the Asiatic congeries is distinct from the African *Isthmia* Walker (|| = *Hilda* Kirkaldy) and that Melichar was entirely justified in describing the genus *Egropa*. *Hilda* is much more similar to true *Tettigometra* in body form. *Isthmia balteata* Distant[5] does not appear to belong to this subfamily, but to Tettigometrinæ, and probably with *Tettigometra tafratensis* Bergevin[6] constitutes a distinct generic group. All African species need careful reëxamination as to anatomical details. To the list of African species should be added *Hilda welwitschi* from Angola, described by Distant.[7]

Synopsis of genera of the subfamily Egropinæ.

a^1. Legs short; in dorsal view, antennæ surpassing eyes by less than eye width; width of head more than two-thirds width of pronotum.

b^1. Body slender, lateral margins of closed tegmina somewhat converging caudad as in typical *Tettigometra*; vertex as long as or longer than pronotum, anteriorly rather strongly angulate between eyes. Africa .... **Hilda Kirkaldy.**
(= *Isthmia* Walker, type *undata* Walker.)

b^2. Body very broad and stout; lateral margins of closed tegmina subparallel; vertex distinctly shorter than pronotum, anteriorly broadly arcuate, not more than slightly obtuse angulate medially between eyes. Indo-Malayan................................ **Egropa Melichar.**
(Type, *inusta* Mel.)

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[5] Insecta Transvaal. **8** (1907) 201.

[6] Bull. Soc. Hist. Nat. Afr. Nord. No. 7 **11** (1920) 102.

[7] Ann. Mag. Nat. Hist. **20** (1917) 186.

*a*². Legs very long and slender; in dorsal view, antennæ surpassing eyes by more than twice eye width; width of head about two-thirds width of pronotum.......... **Mesegropa** g. nov.
(Type, *sumatrensis* sp. nov.)

Genus EGROPA Melichar

This genus is exceedingly homogeneous throughout its range in the Orient. Even the arrangement of its very beautiful color pattern is closely similar through all of the species. There may be a high degree of sexual dimorphism, either in color or structure or both, and there is usually a high degree of variation in shades of color. Distant's color descriptions, without even sex being stated, have made it very difficult to do anything more with Indo-Malayan species until the types have been reëxamined.

The species from West China, described by Melichar[8] as *Isthmia fusca*, was referred to the Tettigometrinæ by Haupt.[9]

In all *Egropa* the tegmina are thick and coriaceous with obscured venation. There are usually three quite distinctly raised, bullate, more or less vitreous areas, a large one at base of corium, another just apicad of the middle of the transverse band which it sometimes invades, and a small one just beyond apex of clavus; the entire apical area beyond level of point of clavus is strongly convex and more or less vitreous.

Synopsis of species of Egropa Melichar.

*a*¹. Vertex relatively shorter and more broadly arcuate, and little deflected; umbo very obtuse angulately prominent (in profile).
  *b*¹. Face basally pale, unicolorous, without black markings; umbo far from apex of vertex, the basal area of face thus nearly as long as wide, the lower area (in profile) nearly parallel to vertex (fide Melichar).......... **E. inusta Melichar.**
  *b*². Face basally black or black marked, this area apically pale margined, or all below pale; umbo proportionally nearer to apex of vertex.
    *c*¹. Legs largely piceous; face with basal area entirely black, beyond chocolate brown.......... **E. davaoensis sp. nov.**
    *c*². Legs pale ochraceous; face pale ochraceous with three large subquadrate black spots at base in both sexes.
      *d*¹. Large, length 5.5 millimeters; inner apical area of tegmina with a row of small ocellate spots, at least in male.
      E. tenasserimensis Distant.

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[8] Ann. Mus. Zool. St. Petersb. 7 (1902) 20.

[9] Wiener Ent. Zeits. 36 (1917) 262.

d^2. Small, length 4 millimeters; inner apical area without ocellate spots in either sex........ **E. fici sp. nov.**

a^2. Vertex relatively longer, obtusely subangulate between eyes, and more or less strongly deflected; facial umbo usually strongly angulate and sometimes produced.

  b^1. Facial umbo of female similar to that of male, more or less acute angled (in profile).

    c^1. Basal area of face clear black or piceous in male, ochraceous in female with three large subquadrate black spots; face below umbo pale, unicolorous........ **E. breviceps** Stål.

    c^2. Basal area of face black in both sexes, with two or four small subcircular pale spots, the black area apically with a conspicuous pale border; face below umbo broadly pale banded, then black across apex........ **E. malayensis** Distant.

  b^2. Facial umbo strikingly different in the sexes, in female produced to twice or more the length of that in male, and longer than distance from umbo to apex of vertex; lower part of face strongly transversely banded, whitish below umbo and black across apex; the basal black area with two small subcircular, submedian, pale spots.

E. jacobsoni Bierman.
E. bengalensis Distant.

Egropa inusta Melichar.

The original figures of this species, published by Melichar,[10] are so diagrammatic that it is impossible to make exact comparisons with other Indo-Malayan species. The coloration, as described, appears to distinguish it from any other Indo-Malayan species. The species was unknown to Distant; he merely copied [11] the description and figure of Melichar. More material of this species is greatly needed.

Egropa davaoensis sp. nov. Plate 1, fig. 1.

Male, length, 3.5 millimeters. Vertex dark ferruginous, the anterior border and entire basal area of face blackish; anterior portion of face ferruginous, paler apically. Pronotum, mesonotum, and middle portion of clavus olive green; anterior and posterior margins of pronotum narrowly white cretaceous (easily rubbed off), and within the posterior white border narrowly blackish. Clavus ferruginous on basal area, the olive green on median area separated by a white line and sordid whitish on apical area, separated by a ferruginous line. Corium (Plate 1, fig. 1) uniformly castaneous, the triangular costal spot shining white, bordered proximad and distad by ferruginous lines; a minute whitish costal dash halfway between this and apex; the dark bullate area beyond apex of clavus is flanked mesad by an irregular elongate white patch, and preceded near claval suture by a subquadrate dark spot. Middle third of tegmina with numerous minute white dots. Legs piceous, femora basally, tibiæ apically, and tarsi ochraceous. Abdomen ochraceous, dark at apex.

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[10] Homop. Ceylon (1903) pl. 3, f. 13.

[11] Fauna Brit. Ind. Rhynch. 3 (1906) 368.

Vertex (Plate 1, fig. 1, *a*) of the short broadly arcuate type, width between eyes distinctly more than twice length; surface areas within posterior lateral angles broadly raised to plane of margins, remainder depressed as usual, surface minutely irregularly wrinkled. Basal area of face minutely, uniformly, vermiculately wrinkled; the facial angle (in profile) very obtuse (Plate 1, fig. 1, *b*), upper and lower margins slightly concave.

MINDANAO, Davao Province, Davao (*Baker*).

The smallest species of the genus known to me.

Egropa tenasserimensis Distant.

Although Distant does not state the sex of the specimen described and figured[12] under this name, it seems to be a male. The row of small ocellate spots near inner apical angle of tegmen may be absent in the female of those species in which it occurs.

Egropa fici sp. nov. Plate 1, fig. 2.

Length, female, 4.5 millimeters; male, 3.5 to 3.75. The sexes are strikingly similar in coloration. Pale ochraceous, with olive greenish shadings on the pale castaneous of vertex, pronotum, mesonotum, and basal half of tegmina; basal area (Plate 1, fig. 2, *b*) with three large subquadrate black spots. Oblique white line on basal third of clavus indistinct. Costal triangular area (this bordered by triangular white stripes) broadly connected with inner pale area (Plate 1, fig. 2, *c*) ; basal bullate area and apical bullate area decolored and vitreous.

Vertex of the short broadly arcuate type, a little longer medially in female (Plate 1, fig. 2, *a*) than in male; in female width between eyes about equaling twice the length; surface evenly concave, minutely roughened, the median line slightly impressed apically. Basal area of face very minutely roughened, the facial angle (in profile) very obtuse, upper and lower margins slightly concave.

LUZON, Laguna Province, Mount Maquiling (*Baker*).

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[12] Fauna Brit. Ind. Rhynch. 6 (1916) 106.

This species occurs occasionally in large colonies on the twigs of *Ficus ulmifolia.* It is apparently the palest-colored species in the genus, and is nearest to *E. tenasserimensis* Distant.

Egropa breviceps Stål.

Remarks on this species were presented by me in 1915.[13] After noting that the colonies of this *Egropa* were intermingled on *Anona* with colonies of *Gargara,* the wholly inexcusable error was made later of figuring the nymph of the *Gargara* for that of *Egropa.* In that paper, therefore, the description and figure of nymph should be credited to *Gargara* sp. This species is the largest and stoutest of the Philippine species.

Egropa malayensis Distant. Plate 1, fig. 3.

Of this well-marked species we have specimens from Penang, from Sandakan, and from Puerto Princesa, Palawan. It is one of the most richly and intensely colored species when fresh. The facial umbo is slightly more prominent in the female than in the male (Plate 1, fig. 3, *c*). We have no females as long as 5 millimeters (fide Distant), the largest being 4.5 millimeters; the males, 4.25; but size varies considerably in both sexes in all of the species.

Vertex (Plate 1, fig. 3, *a*) of the longer, subangulate type, the width between eyes slightly less than twice length, concavity broad and shallow, minutely irregularly wrinkled. Genital segment of female apically narrowly bilobed. The small white spot on costal margin at three-fourths of tegminal length is conspicuously bordered proximad with a dark ferruginous line which is indistinctly sinuately extended across disk. The large triangular costal spot (Plate 1, fig. 3, *e*) is purer white laterally, outside bordered with heavy ferruginous lines; on corium near apex of clavus with several dark subquadrate spots in a longitudinal row, in male only; these spots are variable and may have whitish centers.

Egropa bengalensis Distant. Plate 1, fig. 4.

Specimens taken in Calcutta and sent to me from the Indian Museum evidently belong to this species, described by Distant in 1909[14] and figured in 1916.[15] None of the characters indicated as diagnostic in the last paragraph are really so, since individual and sexual variation might account for all of them. Even the amount of depression and deflection of vertex has to be used with care, due to the fact that in drying the vertex frequently collapses more or less, producing very different appearances within the same species, and sometimes bringing the frontal umbo and point of sunken vertex close together. However, in a highly conspicuous and important character not mentioned by Distant, this species differs widely from all other species excepting only *E. jacobsoni*, described by Bierman[16] from specimens taken at Semarang, Java, on *Cassia fistula* (E. Jacobson). Both of these species have the frontal umbo in the female (Plate 1, fig. 4, *c*) produced in a long porrect horn. Outside of characters variable in all species and differences due to sex, I cannot distinguish between these species as they are characterized by the authors. It seems probable that they are synonymous, but it remains actually to compare Indian and Javan material. Bierman gives what is apparently a quartering view of the female face in which the horn is more long-acute than in Calcutta specimens, though this may be a variable character. Some details of the Calcutta specimens are figured herein (Plate 1, fig. 4, *a* to *g*). The specimen figured by Distant is apparently a male. The green of pronotum and mesonotum may darken to ferruginous in old specimens as in other species, and the castaneous or ferruginous of tegmina become a rich chocolate brown. The three usual bullate areas of corium, one basal, one median, and one near apex of clavus, are blackened.

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[13] Philip. Journ. Sci. § D 10 (1915) 137-140.

[14] Ann. Mag. Nat. Hist. 3 (1909) 41.

[15] Fauna Brit. Ind. Rhynch. 6 (1916) f. 79.

Genus **MESEGROPA** novum

From Mr. J. B. Corporaal comes a single specimen, taken at Medan, Sumatra, of a very extraordinary member of this subfamily, which at first sight was taken for one of the Megaloplastinxinæ. The more angulate head, the great length of second antennal joint (Plate 1, fig. 5, *d*), and the very long slender legs made this resemblance striking. But the head is far shorter in this form than in *Megaloplastinx* and far narrower than pronotum, the second antennal joint is longer, and the face medially umbonate as in *Egropa*.

The general form of body is that of *Egropa*, though longer. Tegmina about three times as long as wide. Forelegs (Plate 1, fig. 5, *e*) longer than tegmina. Second antennal joint (Plate

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[16] Notes Leyd. Mus. 29 (1907) 158, pl. 3. fig. 6. Apparently first noted in Entomol. Berichten, Dl. No. 34 (1907) 2, 162.

1, fig. 5, *d*) more than six times length of first and, in dorsal view, exceeding sides of head by about half entire width of head. Pronotum (Plate 1, fig. 5, *a*) very broadly sinuately arcuate anteriorly, truncate posteriorly; length of mesonotum equaling length of pronotum and vertex together. Width of head about two-thirds that of pronotum. Frontoclypeal suture (Plate 1, fig. 5, *c*) very strongly arcuate and deeply impressed; loræ transverse, very strongly swollen in direct facial view, appearing to extend beyond lateral margins of genæ. Lower area of front strongly transversely wrinkled.

Mesegropa sumatrensis sp. nov. Plate 1, fig. 5.

Male, length, 6.5 millimeters. Ochraceous; legs, lower part of face, and apex of abdomen piceous; vertex infuscated. Pronotum bordered anteriorly and posteriorly with fuscous, the extreme hind margin white. Mesonotum greenish ochraceous (probably olive green when fresh). Tegmina castaneous with dark fuscous shadings; the broad median transverse whitish band is almost equally triangularly expanded on commissure and costa, bordered with dark chocolate brown; basal forber of clavus, outer half of basal bulla (inner half whitish), and a broad area extending mesad from beyond apex of clavus blackened. Apices of tegmina broadly ochraceous.

Vertex (Plate 1, fig. 5, *a*) strongly angulate anteriorly, its length three-fourths of width between the middle of eyes, strongly concave, surface finely obliquely wrinkled. Upper part of face and pronotum very finely irregularly roughened.

SUMATRA, Medan (*Corporaal*).

MEGALOPLASTINXINÆ[17]

Synopsis of genera of the subfamily Megaloplastinxinæ.

a^1. Legs elongate; fore femora and tibiæ subequal; lateral carinæ of vertex more or less laminately raised.
  b^1. Basal margin of pronotum arcuate caudad; clypeus and front (in profile) nearly in same plane, the latter oblique; second antennal joint six times as long as first.................... **Megaloplastinx** Schmidt.
  b^2. Basal margin of pronotum somewhat incurved; clypeus (in profile) forming a reëntering right angle (nearly) with front; the latter nearly horizontal; second antennal joint four times as long as first .... **Euphyonarthex** Schmidt.
a^2. Legs "somewhat short and strong"..................... **Tembandumba** Distant.[18]

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[17] Schmidt, Deutsch. Ent. Zeits. (1912) 459.

[18] Distant, Ann. Mag. Nat. Hist. 20 (1917) 186. In describing this genus Distant does not mention its evident relationships with Schmidt's genera, but says "Allied to Hilda."

ILLUSTRATION

PLATE 1

FIG. 1. *Egropa davaoensis* sp. nov.; *a*, vertex, pronotum, and mesonotum; *b*, side view of head; *c*, tegmen, showing outlines of markings.

2. *Egropa fici* sp. nov.; *a*, vertex, pronotum, and mesonotum; *b*, basal part of face, axial view; *c*, tegmen, showing outlines of markings.

3. *Egropa malayensis* Distant; *a*, vertex, pronotum, and mesonotum; *b*, basal area of face, axial view; *c*, side view of head; *d*, female genitalia; *e*, tegmen, showing outlines of markings.

4. *Egropa bengalensis* Distant; *a*, vertex, pronotum, and mesonotum; *b*, basal area of face, axial view; *c*, side view of female head; *d*, side view of male head; *e*, male genitalia; *f*, female genitalia; *g*, tegmen, showing outlines of markings.

5. *Mesegropa sumatrensis* sp. nov.; *a*, vertex and pronotum; *b*, side view of head; *c*, clypeus, loræ, and rostrum; *d*, antenna; *e*, foreleg; *f*, male genitalia, the hooked gonapophyses pulled out from under plates.

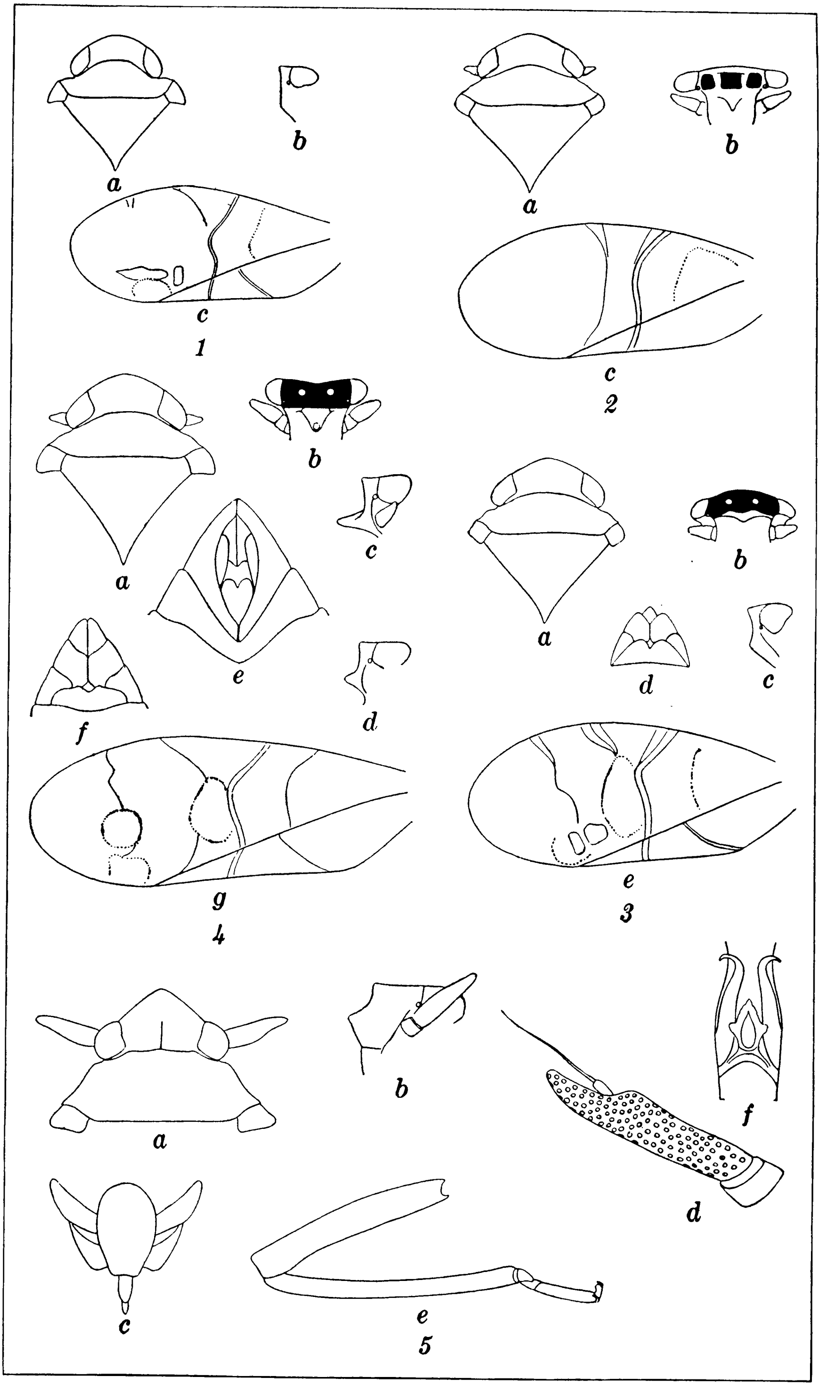

PLATE 1.

EINE NEUE PHILIPPINISCHE EUCHLORA-ART (COLEOPTERA-RUTELIDÆ)

Von FR. OHAUS
Mainz, Germany

EINE TEXTFIGUR

Euchlora cupriventris sp. nov.

Magnitudine et statura *E. smaragdinae,* supra saturate viridigraminea, polita, subtus cum pygidio laeta cuprea, polita, medio pectore, tibiis partim et tarsis viridi-aeneis; supra cum pygidio glabra, subtus pectore sparsim griseo-pilosa. Long, 21-23 mm. ♂ ♀.

NORTHWESTERN PANAY (*Baker*).

Die typischen Stücke befinden sich in der Sammlung von Professor Baker und in der meinigen.

Von allen anderen philippinischen Euchlora-Arten sofort zu unterscheiden durch die fast gras- oder laubgrüne, glänzend polierte Oberseite und das einfarbige, glänzend kupferrote Pygidium. Bei den zwei vorliegenden ♂ ♂ sind die Deckflügel ein wenig heller als der Vorderkörper, bei dem einzelnen ♀ die ganze Oberseite gleichmässig grün, die Basis des Thorax und die Spitze des Schildchens ganz fein kupferig gesäumt; beim ♀ ist die ganze Unterseite und die Beine gleichmässig kupferrot (wie bei *cupripes* Hope) nur die Schienen und Tarsen mit erzgrünen Lichtern; beim ♂ sind die letzteren und die Mitte des Metasternums deutlicher erzgrün. Die Punktierung ist oben überall sehr fein, auf der Afterdecke ebenso auf der Scheibe, nur die Seiten und Spitze sind dicht nadelrissig.

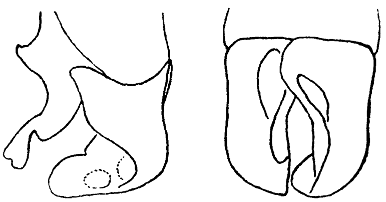

FIG. 1. *Euchlora cupriventris* sp. nov. Forceps.

Am Forceps, Figur 1, sind die etwas asymmetrischen Parameren an der Spitze fast rechtwinkelig nach unten gebogen; die Ventralplatte des Mittelstückes ist ähnlich wie bei der *trigonopyga,* die lappenförmige Spitze jedoch tief ausgerandet.

ILLUSTRATION

Textfigur 1. *Euchlora cupriventris* sp. nov. Forceps.

SOME RARE PHILIPPINE EELS

By Albert W. C. T. Herre

Chief, Division of Fisheries, Bureau of Science, Manila

As stated in my paper on Philippine eels,[1] further collections will greatly increase our knowledge of the apodal fishes of the Archipelago. In the present paper I describe five species which came to hand after my previous article had been sent to the printer, three of which are new to the Philippines.

Genus **CÆCULA** Vahl

Key to the Philippine species of Cæcula.

- a^1. Origin of dorsal above or not far behind gill openings.
  - b^1. Depth 25 to 30 times in length; origin of dorsal one-fourth the length of head behind gill openings .... **C. mindora.**
  - b^2. Depth 18 times in length; origin of dorsal above or very near to gill openings .... **C. taylori.**
- a^2. Origin of dorsal more than half the length of head behind gill openings; depth 45 times in length .... **C. kaupi.**

Caecula kaupi (Bleeker).

Sphagebranchus kaupi Bleeker, Act. Soc. Sc. Indo-Neerl., 5 Twaalfde Bijdr. Celebes 3 (1858–59); Atlas Ichth. 4 (1864) 70, pl. 157, fig. 1; Weber and Beaufort, Fishes Indo-Austr. Arch. 3 (1916) 325.

Depth 45 times, the head 15.5 times in length and 6.5 times in trunk; tail a little longer than head and trunk together; eyes 13 times in head and twice in the small, sharp-pointed snout which is contained 6.5 times in head; mouth wide, 3.7 times in head, lower jaw thin and weak; teeth minute, sharp, pointed backward, in one row, the anterior ones largest; intermaxillary with a row of two similar teeth; a row of eight small teeth on vomer; vertical fins very low, origin of dorsal a little more than 0.8 the length of head behind gill openings; both dorsal and anal expanded near tip of tail, as shown in Bleeker's figure.

The ground color, in an alcoholic specimen, is pale yellow; this is densely punctulated on sides and above with dark dots so that the back is dark olive, which gradually fades out low down on the sides; fins concolorous; a row of light spots along the lateral line.

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[1] Philip. Journ. Sci. 23 (1923) 123–236.

Here described from a specimen, 405 millimeters long, collected by E. H. Taylor about 5 kilometers from the sea in Graan River, on the southern coast of Cotabato Province, Mindanao. My specimen is unquestionably specifically identical with the only other specimen known, which came from a river in Celebes.

Genus **ACHIROPHICHTHYS** Bleeker

Achirophichthys BLEEKER Ned. Tijdschr. Dierk. 2 (1864) 41.

The elongate body rather stout and nearly cylindrical, tail a little longer or shorter than head and trunk together; head small or of medium size, with pointed snout and weak jaws, the lower equal to or shorter than the upper; eyes small, well forward; anterior nostrils not tubulate, but merely with a prominent rim; lips not fringed or with but one row of minute tubercular papillæ; teeth of unequal size, those on vomer wholly or partially caniniform; mandibles with a single row of teeth, and some canines anteriorly; intermaxillary plate with canines; maxillary teeth in one or two rows; no pectorals; origin of dorsal rather close to gill openings, or not more than one-third the length of head behind them; gill openings wide, low down on side.

This genus, not hitherto known from the Philippines, contains two species, one from Celebes and one from New Guinea, with but a single specimen previously recorded for each.

Achirophichthys kampeni (Weber and Beaufort).

Brachysomophis kampeni WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 316, figs. 150 and 151.

Depth contained about 24.7 times in length, head a trifle more than 8 times, and 2.9 in trunk; head and trunk together a tenth their own length shorter than tail; eyes small, covered with skin, more than 19 times in head and nearly 2.5 times in narrow and pointed snout; mouth large, reaching far behind eye, its gape more than 2.8 in head; a single row of slender, compressed, recurved teeth in maxillaries; a curved row of five canines around anterior margin of intermaxillary plate; three large canines on vomer, with two very small teeth between first and second and second and third, and a single small tooth behind the last one; a single row of teeth on mandible, slightly larger than those of upper jaw, those of anterior half rather widely spaced, and with two or three pairs of canines at anterior extremity.

Trunk full and robust with head of the same character but with weak pointed jaws and snout; distance from origin of dorsal to gill openings equal to distance from posterior margin of eye to tip of snout; both dorsal and anal low, about equal in height, extending almost to tip of tail, as shown in fig. 150, cited above. Lower jaw much shorter than upper, so that the intermaxillary teeth are well forward of and overlap mandible when it is closed.

Dark olive brown above, yellow below the conspicuous lateral line, which is marked by a row of circular yellow dots. Dorsal fin dark like back, anal fin yellow like belly.

Here described from a specimen, 395 millimeters in length, obtained at Lamug, a barrio of Peñablanca, from Pinacanauan River, a small stream which flows into Cagayan River at Tuguegarao, Cagayan Province, Luzon. It must be fairly common in this region, as it seems to be known to the people, although I only succeeded in securing one specimen. Hitherto known only from a specimen, 323 millimeters long, collected in Humboldt Bay, New Guinea, and preserved in the Zoölogical Museum of Amsterdam. It differs from my example in having the head and trunk somewhat longer than the tail.

Cirrhimuræna oliveri (Seale).

In a collection of eels made by E. H. Taylor on a coral reef at Despujol, Tablas, I discovered a fine specimen of this rare little fish, hitherto known only from the type, collected by Alvin Seale at Zamboanga.

Length, 500 millimeters; depth 40 times, head 13.13 times in length and 4 times in trunk; head and trunk contained 1.63 times in the very slender elongate tail, which is 62 per cent of total length; eyes small, 2.5 times in the narrow, convex snout, which is 6⅓ times in head; mouth large, about 3 times in head; pectoral 3.45 in head; three rows of fine sharp pointed teeth on maxillaries, apically passing into a broad band of four rows on vomer; intermaxillary plate with a marginal row of thirteen teeth and a central row of four slightly longer teeth; mandibles with three rows of coarser teeth anteriorly, passing into two rows of finer teeth posteriorly; a broad toothless space at symphysis.

This very distinct species is distinguished at a glance from all other members of the genus by the origin of the dorsal, which is anterior to the gill openings by the length of the pectoral in the type, and one and a half times the length of the pectoral in the Tablas specimen.

Gymnothorax polyuranodon Bleeker.

Muræna polyuranodon BLEEKER, Nat. Tijdschr. Ned. Ind. 5 (1853) 248; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 369, fig. 185.

Gymnothorax polyuranodon BLEEKER, Atlas Ichth. Muræn. 5 (1864) 89, pl. 174, fig. 2.

Among the fishes obtained by E. H. Taylor along the southern coast of Cotabato Province, Mindanao, were three specimens of this eel, hitherto unrepresented in the Bureau of Science collections. Two of them, 475 and 380 millimeters long, respectively, were from Craan River, and one, 275 millimeters long, was collected in Saub River. In each instance they were about 4 kilometers from the sea. The following description is taken from the largest specimen.

Depth 25 in total length; head 9.5 times, 4 times in trunk, and 4.5 times in tail, which is half the length of head shorter than head and trunk together; eyes about 14 times in head and twice in snout, placed about halfway between tip of snout and the angle of the wide mouth, which goes 3⅓ times in head; teeth numerous, their sharp points curved backward, in two rows in maxillaries, those of the inner row larger; intermaxillary plate with two rows, the inner teeth longer, and with two longer, strongly recurved, depressible teeth in a central row; vomer with a single row of four small teeth (nine in the next larger specimen); teeth in mandible in two rows, these very close together posteriorly but wide apart and much larger anteriorly, those of the inner row very much longer and stronger.

An elongate eel with strongly compressed trunk, the tail especially so, the skin thick and leathery; snout short, narrow, jaws equal, but lower one sometimes curved so that it cannot meet upper one closely; head small, narrow, but with occipital region strongly elevated; gill openings nearly twice as large as eyes; origin of dorsal just anterior to gill openings; dorsal and anal low, little developed except on tail and nowhere conspicuous.

The color in alcohol is yellowish brown, everywhere covered with more or less rounded, often confluent and irregular black spots; on the head they unite into more or less clearly defined narrow longitudinal bands, separated by pale longitudinal streaks of the ground color, especially well defined on the sides and throat.

A handsome and very well defined species.

Ophichthus evermanni Jordan and Richardson.

Ophichthus cephalozona variety GÜNTHER, Cat. Fishes Brit. Mus. 8 (1870) 70.

Ophichthus evermanni JORDAN and RICHARDSON, Cat. Fishes of Formosa, Memoirs Carnegie Museum 4 (1909) 172, pl. 67, upper figure.

Depth 24 times, head 9.7 times in total length; head 4.1 times in trunk, and head and trunk together longer than tail which goes 1.1 times in them; snout slightly longer than breadth of interorbital space and 5.85 times in head; the eye is 10.25 times in head and 1.75 in snout; gape 3.15 times in head, reaching well behind eyes.

Body robust, full and rounded, its transverse diameter nearly equal to its depth, the tail stout and rather blunt; snout convex, blunt, interorbital space nearly flat; eyes full, circular; pectorals broad, short, their length 4.1 in head; origin of dorsal over the middle of pectorals; four teeth, irregularly disposed on intermaxillary plate; teeth in jaws and on vomer one-rowed, pointed, curved, fixed.

Color in alcohol rich purplish brown, more or less white under head and on belly; body marked dorsally and on sides with many irregular dark brown blotches and bands which extend on to dorsal fin; there is a very large but poorly defined blackish blotch on nape; a large bluish white blotch extends up on each side from belly toward nape, partially separating it from the dark olive crown and snout; there are traces of pale patches behind the nuchal blotch also; margin of dorsal white; anal fin pale.

This handsome eel is readily separable from *O. cephalozona* and occurs from Cebu to southern Japan. It is here described from a very fine specimen, 798 millimeters in length, collected at Alaminos, Pangasinan Province, Luzon.

PLANTS FROM BANGUEY ISLAND

By ELMER D. MERRILL

Director and Botanist, Bureau of Science, Manila

Mr. D. D. Wood, conservator of forests, British North Borneo, and party made a small collection of plants on Banguey Island in October, 1922, this material apparently being the first botanical collection made on that island. Banguey is situated off the extreme northeast coast of Borneo, and forms a part of the southern boundary of Balabac Strait, separating Borneo from the Philippines; politically, it is a part of British North Borneo. The small collections available indicate that its flora is intermediate between that of the Philippine group and Borneo, but with rather more numerous Philippine elements than would be expected.

ARACEAE

AMORPHOPHALLUS RIVIERI Durieu var. **KONJAC** (C. Koch) Engl.

No. 1127, in damp alluvial soil. Japan to Indo-China and the Philippines.

PALMAE

CALAMUS JAVENSIS Blume var. **WOODII** var. nov.

Forma distincta, foliis oblongo-ellipticis, circiter 20 cm longis, 5.5 ad 7 cm latis, sessilibus, inflorescentiis ♂ laxissimis.

No. 1111, in forests, Libuak Valley. In placing this under *Calamus javensis* Blume I have followed Beccari in his very broad interpretation of Blume's species. It seems to be most closely allied to *Calamus javensis* Blume var. *peninsularis* Blume of the Malay Peninsula. Complete material may show it to be amply distinct.

ZINGIBERACEAE

COSTUS SERICEUS Blume.

No. 1108, in hilly regions. Burma to Java, the Philippines, and New Guinea. *Rintubu* (Dusun).

ORCHIDACEAE

GEODORUM NUTANS (Presl) Ames (*G. semicristatum* Lindl.).

No. 1116, Limbuak Valley at low altitudes. Common and widely distributed in the Philippines but hitherto unrecorded from outside of the Archipelago. The genus is new to Borneo.

HABENARIA HYSTRIX Ames (*H. muricata* Vidal).

No. 1117, Limbuak Valley. Widely distributed in the Philippines but hitherto unrecorded from outside of the Archipelago.

MORACEAE

ANTIARIS TOXICARIA (Pers.) Lesch.

No. 1135, in hilly regions, Limbuak Valley. India to southern China, through Malaysia to the Philippines and the Moluccas. The sap, mixed with the juice of a vine, is used for poisoning arrows. *Ipoh* (Malay), *dalit* (Dusun).

ANONACEAE

GONIOTHALAMUS WOODII Merr.

No. 1129, in forests at low altitudes. Borneo.

UVARIA MICRANTHA (DC.) Hook. f. & Th.

No. 1122, Limbuak Valley. Burma and Indo-China to Sumatra, Borneo, and the Philippines. *Tient* (Dusun).

UVARIA PURPUREA Blume.

No. 1134, without data. Southern China to the Malay Peninsula and Archipelago.

LEGUMINOSAE

ALBIZZIA RETUSA Benth. (*A. littoralis* Teysm. & Binn.).

No. 1118, along the seashore at Petongan, the bark used by the natives as a soap substitute. Nicobar Islands through Malaysia to the Carolines, but not as yet recorded from Borneo proper. *Langir kayo* (Malay).

ENTADA PHASEOLOIDES (Linn.) Merr. (*E. scandens* Benth.).

No. 1119, Limbuak Valley. Pantropic in various forms, the typical form widely distributed in Malaysia. *Baligo* (Dusun).

EUPHORBIACEAE

ANTIDESMA BANGUEYENSE sp. nov.

Arbor parva, circiter 5 m alta ramulis et subtus foliis et inflorescentiis plus minusve pubescentibus; foliis oblongis ad oblongo-ovatis, 11 ad 14 cm longis, 4 ad 5.5 cm latis, chartaceis ad subcoriaceis, apice perspicue acuminatis apiculatisque, base obtusis ad subrotundatis, supra, costa excepta, glabris, olivaceis, nitidis, subtus pallidioribus, pubescentibus, nervis utrinque circiter 8, subadscendentibus, supra leviter impressis, subtus valde perspicuis; petiolo 4 mm longo, pubescente, stipulis anguste lanceolatis, pubescentibus, deciduis, petiolo aequantibus; infructescentiis solitariis, terminalibus vel in axillis superioribus, racemosis, 7 ad 10 cm longis, pubescentibus; floribus 5-meris, sepalis persistentibus lanceolatis, circiter 1 mm longis, pedicellis 1.5 mm longis; fructibus subovatis, obliquis, subcompressis, perspicue reticulatis, distincte ciliatis, apice obtusis, leviter oblique rostratis, basi rotundatis.

No. 1121, Limbuak Valley, at low altitudes. A species apparently belonging in the same group with the Bornean *Antidesma foxworthyi* Merr., from which it differs radically in its smaller, pubescent leaves and in its pubescent fruits.

WETRIA MACROPHYLLA (Blume) J. J. Sm.

No. 1124, Limbuak Valley. Luzon, Bancalan, and Negros in the Philippines, Borneo, Sumatra, and Java. *Rambay utan* (Malay.)

VITACEAE

TETRASTIGMA LOHERI Gagnep.

No. 1128, at low altitudes in Limbuak Valley. This species is widely distributed in the Philippines, extending from northern Luzon to Palawan and Mindanao; it has hitherto not been recorded from outside of the Archipelago.

FLACOURTIACEAE

PANGIUM EDULE Reinw.

No. 1120, along the Pankulan River. Throughout Malaysia, often planted. *Rangi* (Dusun), *kapayang* (Malay).

LYTHRACEAE

LAGERSTROEMIA SPECIOSA (Linn.) Pers.

No. 1105, at low altitudes, Limbuak Valley. India to tropical Australia. *Tibaba* (Dusun).

MYRTACEAE

DECASPERMUM FRUTICOSUM Forst. (*D. paniculatum* Lindl.).

No. 1109, at low altitudes. India to tropical Australia and Polynesia.

ARALIACEAE

SCHEFFLERA INSULARUM (Seem.) Harms.

No. 1112, Limbuak Valley. Common and widely distributed in the Philippines from central Luzon to Mindanao, but not previously recorded from outside of the Archipelago.

MYRSINACEAE

DISCOCALYX PALAWANENSIS Elm.

Nos. 1125, 1130, Limbuak Valley, at low altitudes. Palawan. *Mationg* (Dusun).

EMBELIA PHILIPPINENSIS A. DC.

No. 1113, in thickets or forests at low altitudes. Widely distributed in the Philippines, but hitherto not recorded from outside of the Archipelago.

ACANTHACEAE

THUNBERGIA FRAGRANS Roxb.

No. 1110, in thickets at low altitudes. India to Australia.

RUBIACEAE

IXORA GRANDIFOLIA Zoll. & Mor.

No. 1106, Limbuak Valley, at low altitudes. The specimen is with very young buds but is probably referable here. The species is widely distributed in western Malaysia but has not been found in the Philippines.

IXORA sp.

No. 1123, with the preceding, but with fruits only.

MUSSAENDA VILLOSA Wall.

No. 1114, on hills, Limbuak Valley. The specimens are imperfect but are probably referable to Wallich's species which occurs in the Malay Peninsula. *Daliadak* (Dusun), *kinabudan* (Malay).

PETUNGA RACEMOSA (Roxb.) K. Schum.

No. 1115, at low altitudes. India to Borneo and Java, extending into the Philippines in Balabac and Palawan.

TARENNA CUMINGIANA (Vidal) Elm. Leafl. Philip. Bot. 5 (1913) 1898.

No. 1107, from low altitudes. *Ramos 1335* from British North Borneo, identified and distributed as *T. winkleri* Val., is the same. Widely distributed in the Philippines but hitherto not recorded from outside of the Archipelago. *Baguiran* (Dusun).

TAXONOMIC VALUE OF HAIR IN CHIROPTERA

By HOWARD IRVING COLE

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TWO PLATES

The hair of all the available species of Philippine bats[1] was examined microscopically, in the hope that a morphological study might bring to light characteristics of taxonomic value. The work presented here has not warranted the drawing of conclusions, as it is of a purely preliminary character; but, on the other hand, this study may prove to be suggestive, and I hope it may lead to a more complete and detailed examination of the hair of Chiroptera in its relation to taxonomy.

The hair of mammals can be broadly divided into two types; namely, the fur, or under hair, and the protective, or over hair. The former constitutes the major portion of the body covering and is ordinarily much finer and clearer than the protective hair. Hausman[2] has shown that the hairs of mammals differ markedly in morphologic characteristics.

In identifying hair species it is necessary to compare the scales and medulla from the same part of the hair, since the form of the scale changes from the base to the top of the hair shaft. In the examination of the hairs of the bat species enumerated below hair specimens were taken from the region of the median line of the dorsum just below, that is, caudad of the shoulders, as suggested by Hausman. The hairs were thoroughly washed in a mixture of equal parts of 95 per cent alcohol and chloroform. Difficulty in distinguishing the shape of the scales when the hair was mounted in air was overcome by staining with an alcoholic solution of gentian violet.[3]

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[1] Twenty-four species were examined. This is somewhat less than half the number enumerated by Hollister, Philip. Journ. Sci. § D 7 (1912) 7.

[2] Hausman, L. A., Am. Journ. Anat. 27 (1920) 463; Journ. Am. Mus. Nat. Hist. 20 (1920) 434; Am. Naturalist 54 (1920) 509; Scientific Monthly 12 (1921) 215.

[3] Hausman, L. A., Am. Naturalist 54 (1920) 519.

In order to observe the medulla the hairs were washed as before in an alcohol-chloroform mixture, then with xylol, and mounted in thin Canada balsam.

The 4 millimeters objective and the 7.5 ocular were usually used in the microscopical examination. By using reflected and transmitted light discriminatingly the air-mounted specimens show clearly the shape of the scales, while the balsam-mounted specimens show the medulla (when present) and the pigmentation of the cortex layer. Very few of the bat (fur) hairs contained a medulla. In fact, of those examined only the Pteropidæ and Megadermidæ showed the presence of medulla.

The systematic positions of the species of bats from which hair was examined are shown in the following list:

MEGOCHIROPTERA

PTEROPIDÆ

PTEROPINÆ

Cynopterus brachyotis (Müller).
Rousettus amplexicaudatus (Geoffroy).
Acerdon jubatus (Eschscholtz).
Acerdon jubatus (?).

MACROGLOSSINÆ

Macroglossus lagochilus Matschie.
Eonycteris robustus Miller,

MICROCHIROPTERA

EMBALLONURIDÆ

EMBALLONURINÆ

Taphozous philippinensis Waterhouse.

MEGADERMIDÆ

Megaderma spasma (Linnæus).

RHINOLOPHIDÆ

Rhinolophus virgo Andersen.
Rhinolophus rufus Eydoux and Gervais.

HIPPOSIDERIDÆ

Hipposideros diadema griseus (Meyen).
Hipposideros pygmaeus Waterhouse.

VESPERTILLIONIDÆ

VESPERTILLIONINÆ

Myotis macrotarsus (Waterhouse).
Myotis sp.[4]
Myotis sp.[4]
Pippistrellus abramus (Temminck).
Pippistrellus sp.[4]
Scotophilus temminckii (Horsfield).

MINIOPTERINÆ

Miniopterus tristis (Waterhouse).
Miniopterus eschscholtzii (Waterhouse).
Miniopterus paululus Hollister.

KERIVOULINÆ

Kerivoula sp.[4]

MOLOSSIDÆ

Chaerophon luzonus Hollister.

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[4] This form probably represents an undescribed species.

The fur hairs of these species are illustrated in the accompanying plates. The hairs are all drawn to the same scale, 400 magnification. Each figure contains a diagram of the hair as seen in air and in balsam, to show the form of scale, the medulla, and the pigmentation.

Plate 1, figs. 1 to 7, inclusive, shows the type of fur hair common to the Pteropidæ. The cuticular scales are coronal and slightly serrated. The medulla is discontinuous, simple, and ovate.[5] The pigmentation is finely dotted, grouped in streaks.

Plate 1, fig. 8, shows the only specimen of hair of the family Emballonuridæ. The cuticular scales are coronal and regularly serrated. There is no medulla. The pigmentation is finely dotted in short streaks.

The family Megadermidæ is represented by *Megaderma spasma,* shown in Plate 1, fig. 9. The fur hair of this species has coronal, slightly serrated cuticular scales, and a discontinuous ovate medulla. The hairs from two species of Rhinolophidæ are shown in Plate 1, figs. 10 and 11. The cuticular scales are coronal and slightly serrated. There is no medulla. The pigmentation of both species is finely dotted in longitudinal streaks.

The hairs of *Hipposideros diadema* and *H. pygmaeus* are shown in Plate 1, fig. 12, and Plate 2, fig. 13. The hairs of these two species are very similar, with coronal, simple, cuticular scales, no medulla, and finely dotted pigment grouped in longitudinal streaks.

Ten species of the family Vespertillionidæ are illustrated (Plate 2, figs. 14 to 23). The type of pigmentation varies within the family, as shown in the figures, the dots in some of the genera being grouped longitudinally and in some, transversely. The cuticular scale form and the type of pigmentation are very similar in the three species of the genus *Myotis.* This is also true for the genus *Miniopterus.* All the specimens of Vespertillionidæ, except *Scotophilus temminckii* and *Kerivoula* sp., have pigment granules grouped transversely. From the viewpoint of the type of pigmentation of the hair the genus *Scotophilus* appears to be more closely related to the genus *Kerivoula* than to *Myotis* and *Pippistrellus.*

The hair of *Chaerophon luzonus* of the Molossidæ is shown in Plate 2, fig. 24. The cuticular scales are coronal and dentated.

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[5] See Hausman's classification of hair, Am. Naturalist 54 (1920) 505.

There is no medulla. The cuticular scales of this hair are the most elaborate of any of those examined.

There seems to be little hope that the morphological characters of the fur hair can be used to aid in the differentiation of species of bats, but a more complete study might well lead to the use of fur hair as an added characteristic in the classification of the genera of Chiroptera. In the specimens examined the type of pigmentation and cuticular scale did not vary within the genus, but did vary within the family.

My thanks are especially due to Mr. Edward H. Taylor, who furnished the specimens of hair used in this work and whose kindly advice was invaluable to me in the preparation of this study.

ILLUSTRATIONS

Fur hairs of Chiroptera as seen under the microscope, mounted in air and in balsam; magnification, × 400.

PLATE 1

FIG. 1. *Cynopterus brachyotis.*
2. *Rousettus amplexicaudatus.*
3. *Rousettus amplexicaudatus.*
4. *Acerdon jubatus.*
5. *Acerdon jubatus ?*
6. *Macroglossus lagochilus.*
7. *Eonycteris robustus.*
8. *Taphozous philippinensis.*
9. *Megaderma spasma.*
10. *Rhinolophus virgo.*
11. *Rhinolophus rufus.*
12. *Hipposideros diadema griseus.*

PLATE 2

FIG. 13. *Hipposideros pygmaeus.*
14. *Myotis macrotarsus.*
15. *Myotis* sp.?
16. *Myotis* sp.?
17. *Pippistrellus abramus.*
18. *Pippistrellus* sp.?
19. *Scotophilus temminckii.*
20. *Miniopterus tristis.*
21. *Miniopterus eschscholtzii.*
22. *Miniopterus paululus.*
23. *Kerivoula* sp. ?
24. *Chaerophon luzonus.*

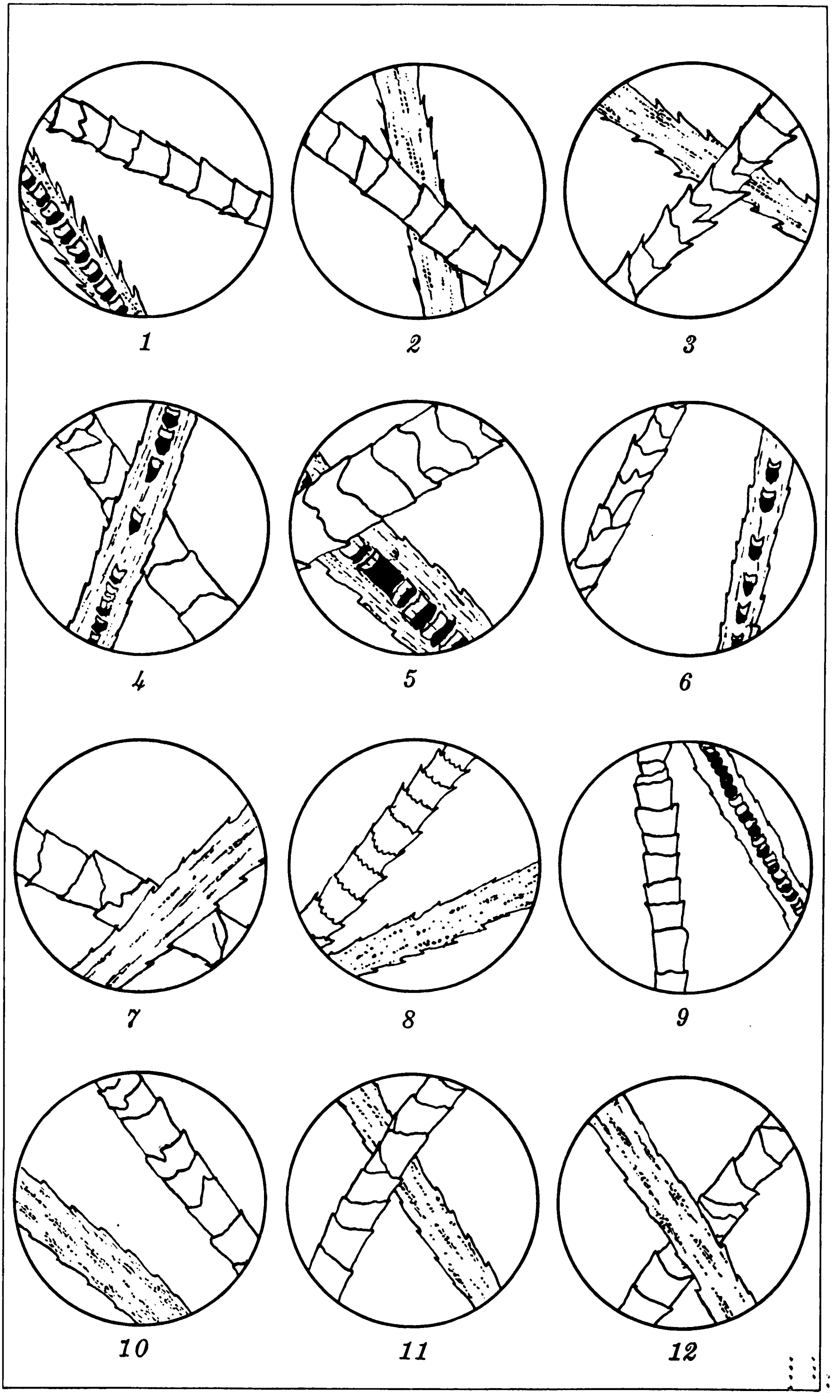
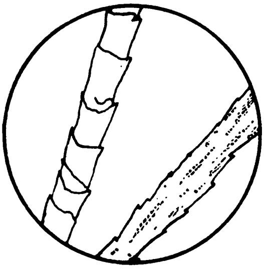


PLATE 1.



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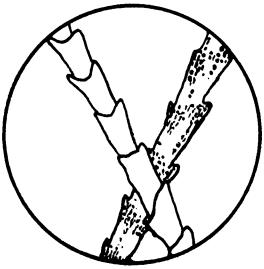

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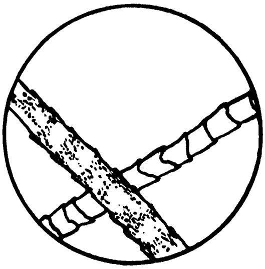

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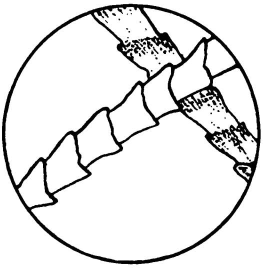

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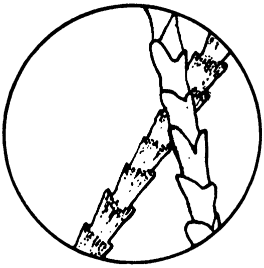

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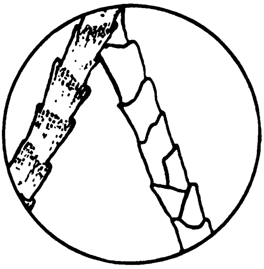

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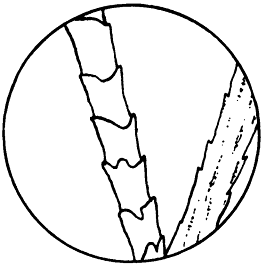

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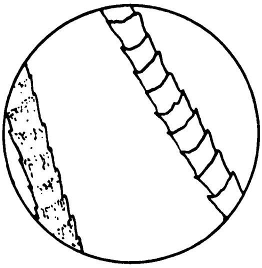

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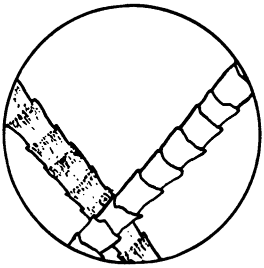

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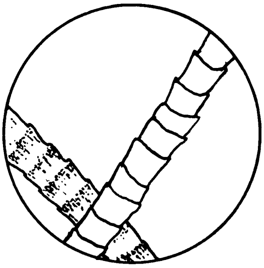

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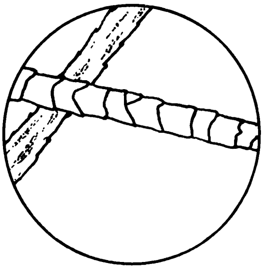

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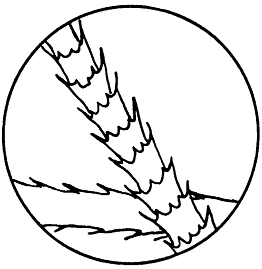

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PLATE 2.

OXIDATION OF LUMBANG AND LINSEED OILS, AND OF THE PRINCIPAL COMPOUNDS IN LUMBANG OIL

By A. P. West

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and

Antonio I. de Leon

Instructor in Chemistry, University of the Philippines

ONE PLATE

INTRODUCTION

Drying oils have the characteristic property of absorbing oxygen and drying to an elastic skin when exposed in a thin layer to the air. Although a number of investigations have been carried out to ascertain the exact mechanism of the drying process, the chemical changes involved are but very imperfectly understood. Most of the important work on the drying of oils has been done with linseed, the most widely used drying oil, and brief reviews of the literature are given by Lewkowitsch, Friend, and Livache and McIntosh.[1]

Lumbang (candle-nut) oil, as a drying oil, appears to be equally as good as linseed oil for the manufacture of paints, varnishes and similar products. The composition (Table 1) of lumbang oil is somewhat similar to that of linseed oil, in that both oils consist of a mixture of unsaturated glycerides (linolenic, linolic, and oleic) and contain also glycerides of saturated acids. It seemed that lumbang oil might serve as excellent material for studying the oxidation (drying) process, since it consists almost entirely of unsaturated glycerides. Moreover, as it contains a much smaller percentage of saturated glycerides than does linseed oil the approximate composition of the partially oxidized oil is more easily determined in the case of lumbang than in that of linseed oil.

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[1] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 3 (1915) 177; Friend, J. N., The Chemistry of Linseed Oil (1917); Livache, Ach., and McIntosh, J. G., The Manufacture of Varnishes and Kindred Industries 1 (1919).

As a preliminary investigation of the chemical changes involved in the oxidation (drying) process we thought it might, perhaps, be of interest to determine the comparative oxygen absorption of lumbang and linseed oils oxidized under the same conditions. It also seemed that data obtained by analyzing samples of lumbang oil oxidized for various periods of time might be of interest in showing the relative oxidation of the principal compounds in lumbang oil.

When linseed or lumbang oil dries, oxygen of the air is not only absorbed by the oil and fixed permanently, forming a nonvolatile, solid, elastic skin called linoxyn, but oxygen also reacts with the oil to form volatile products which escape in the air. The drying process tends then to separate the oil into two portions, one of which is volatile and the other nonvolatile. A thorough study of the oxidation (drying) process should include investigations of the nonvolatile portion of the oxidized oil, the volatile products, and also the quantity and rapidity of oxygen absorption.

HISTORICAL REVIEW

Researches [2] on blown linseed oil have shown that the volatile products consist mostly of water, carbon dioxide, formic and acetic acids, and certain aldehydes.

Although the chemistry of the nonvolatile portion of linseed oil has not been worked out in a satisfactory manner, Lewkowitsch [3] states that when linseed oil dries the final product appears to be the same, whether raw linseed oil is allowed to absorb oxygen slowly from the atmosphere, the drying accelerated by previously boiling the raw oil (boiled oil), or a current of oxygen passed through the raw oil at an elevated temperature producing blown oil.

The commercial valuation of an oil suitable for the manufacture of paint and varnish depends on its drying power. This is determined principally by the time required for drying to an elastic skin. The method that has been commonly employed for determining the relative oxygen absorption, or drying power, of an oil is known as the "glass plate" method. In this method the oil is spread in a thin layer on a glass plate, exposed to the atmosphere, and the time required for drying ascertained. For comparative data duplicate tests are made with an oil of known quality. The method does not give absolutely accurate results since the data obtained vary with the thickness and uniformity of the oil layer, the quantity of oil used, and various other factors. Even if weighed quantities of oil are employed the increase in the weight of the oil represents only the apparent oxygen absorption and not the actual amount of absorbed oxygen since volatile products, which escape during the drying process, cause a loss in weight. Again, the "glass plate" method does not give accurate data as to the exact mechanism of the oxidation process and the composition of the oxidized oil.

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[2] Friend, J. N., The Chemistry of Linseed Oil (1917) 50.

[3] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 3 (1915) 177.

As to the absorbed oxygen that is fixed permanently by the nonvolatile portion of the oxidized oil during the drying process, it seems that in some way it saturates the double bonds of the unsaturated compounds contained in the oil. The formulas that have been suggested for the unsaturated acids, which are present as glycerides in linseed and lumbang oils, are as follows:

$$CH_3{\cdot}CH_2{\cdot}CH{=}CH{\cdot}CH_2{\cdot}CH{=}CH{\cdot}CH_2{\cdot}CH{=}CH{\cdot}(CH_2)_7\ COOH$$

Linolenic acid.

$$CH_3{\cdot}(CH_2)_4{\cdot}CH{=}CH{\cdot}CH_2{\cdot}CH{=}CH{\cdot}(CH_2)_7\ COOH$$

Linolic acid.

$$CH_3{\cdot}(CH_2)_7{\cdot}CH{=}CH{\cdot}(CH_2)_7\ COOH$$

Oleic acid.

If it is true that, in drying, the absorption of oxygen takes place at the double bonds, then linolenic glyceride, containing nine double bonds, should absorb oxygen more readily than linolic glyceride which contains six double bonds, and the latter more readily than oleic which contains only three double bonds.

A certain proportion of the oxidized glycerides, which are present in blown linseed oil, may be decomposed into their corresponding oxyacids. The latter substances, known as Fahrion's oxyacids,[4] are characterized by their insolubility in petroleum ether. Formulas of these oxyacids have not as yet been worked out in a satisfactory manner.

Some authorities are inclined to think that, in the saturation of the double bonds, peroxides are formed and that these substances act as autocatalysts and accelerate the oxidation reaction (drying); that is, the peroxide (autocatalyst) acts as a carrier of oxygen from the air to the oil which is the acceptor (theory of Engler and Weissberg). According to this view the drying process is, then, an autocatalytic reaction.

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[4] Livache, Ach., and McIntosh, J. G., The Manufacture of Varnishes and Kindred Industries 1 (1919) 78 and 96; Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 592.

The experiments of Genthe [5] on the drying of linseed oil gave figures which seemed to correspond approximately to the equation for an autocatalytic reaction. From these results it would appear that drying is, perhaps, an autocatalytic process. Genthe was inclined to think that the autocatalyst had the character of a peroxide, though he did not isolate such a compound.

The foregoing brief discussion will, perhaps, give some idea of the more important suggestions that have been advanced to explain the peculiar property of drying which is a characteristic of vegetable drying oils.

LUMBANG OIL

In most of the oxidation experiments recorded in this paper Philippine lumbang (candle-nut) oil was used though, for comparison, some experiments were made with linseed oil. Lumbang oil is obtained from the seeds of *Aleurites moluccana*, which is a large tree reaching a diameter of 80 to 160 centimeters. *Aleurites moluccana* is fairly abundant in a wild state in many parts of the Philippines and can be grown readily in plantations. It is also distributed through Polynesia, the Malayan region, and the Hawaiian Islands.

The constants and general properties of lumbang oil have been determined by various investigators.[6] The determination of oil constants showed that lumbang oil, like linseed, is characterized by high iodine and saponification values.

Brill and Agcaoili,[7] and also Aguilar,[8] caried out a few experiments to determine the drying properties of lumbang oil as compared with linseed oil. They used the "glass plate" method, and their results indicated that lumbang oil compares favorably with linseed oil in the rate of drying and quality of film.

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[5] Genthe, A., Zeits. für Angew. Chem. 19 (1906) 2087.

[6] Richmond, G. F., and Rosario, M. V. del, Philip. Journ. Sci. § A 2 (1907) 439; Wilcox, E. V., and Thompson, A. R., Press Bull., Hawaii Agr. Exp. Station 39 (1913); Brill, H. C., and Agcaoili, F., Philip. Journ. Sci. § A 10 (1915) 111; Aguilar, R. H., Philip. Journ. Sci § A 12 (1917) 235 and 14 (1919) 275; West, A. P., and Brown, W. H., Bull. P. I. Bur. Forestry 20 (1920) 121; West, A. P., and Montes, Z., Philip. Journ. Sci. 18 (1921) 619; West, A. P., and Gonzaga, L., Philip. Journ. Sci. 23 (1923) 277; West, A. P., and Smith, F. L. 2d., Bull. P. I. Bur. Forestry 24 (1923).

[7] Brill, H. C., and Agcaoili, F., Philip. Journ. Sci. § A 10 (1915) 119.

[8] Aguilar, R. H., Philip. Journ. Sci. § A 12 (1917) 237.

Various commercial products[9] such as paints, varnishes, putties, soaps, and printing inks have been made from lumbang and linseed oils under identical conditions. Raw, boiled, and blown lumbang and linseed oils were used in making these various products. Boiled and blown oils containing driers were also employed. The results showed that the method of treatment, whether boiling or blowing with or without driers, affected both oils in apparently the same manner. As a drying oil, lumbang appeared to be just as good as linseed and either oil can be used as an efficient substitute for the other.

It is well known that the oxygen absorption of an oil is closely related to the iodine value; in fact, as pointed out by Lewkowitsch,[10] a rough proportionality exists between the quantity of oxygen actually absorbed by an oil and the amount calculated by multiplying the iodine value by the factor 0.063. A determination of the iodine value of an oil that is being oxidized gives, then, an idea of the amount of oxygen absorbed. Experiments[11] have been carried out on the oxidation of lumbang oil by allowing a slow current of dried air to pass through the oil which was heated and stirred constantly. At frequent intervals samples of the oxidized oil were taken and determinations made of various constants such as the iodine and saponification values. As a result of continued oxidation a considerable quantity of volatile gases was evolved and the nonvolatile portion of the oil became very thick and viscous. The specific gravity, acid, and saponification values increased, while the iodine value decreased.

Analyses of lumbang and linseed oils are given in Table 1. The composition of lumbang oil was determined by West and

TABLE 1.—*Composition of lumbang and linseed oils.*

Glyceride.	Lumbang oil.	Linseed oil.
Unsaturated glycerides:	*Per cent.*	*Per cent.*
Linolenic	6.5	39.7
Linolic	33.5	31.4
Oleic	57.0	18.3
Saturated glycerides	[a] 2.8	9.7
Total	99.8	99.1

[a] The figure 2.8 may perhaps represent oxidized glycerides.

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[9] West, A. P., and Smith, F. L. 2d, Bull. P. I. Bur. Forestry 24 (1923).

[10] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 478.

[11] West, A. P., and Montes, Z., Philip. Journ. Sci. 18 (1921) 619.

Montes[12] who used the lead-salt-ether method[13] to separate the saturated from the unsaturated acids in lumbang oil, and the bromo-derivative method[14] to separate the unsaturated acids from each other. In this analysis of lumbang oil the percentage of saturated glycerides is given as 2.8. In making this analysis no special precautions were taken to protect the solutions and perhaps the glycerides, reported as saturated, were really oxidized glycerides which were formed during the analysis or were present in the original oil. The lead salts of the oxidized acids are insoluble in ether and, if oxidized acids are present, they would go with the saturated acids in the lead salt separation. Subsequent analyses of lumbang oil indicated that these glycerides were perhaps not saturated, but rather oxidized compounds. Lewkowitsch[15] records various analyses of linseed oil, one of which, given in Table 1, was worked out in round numbers of Fahrion. His results, expressed in percentage of acids, have been recalculated to the glycerides originally present in the oil. In this analysis of linseed oil the percentage of linolenic glyceride is given as 39.7 which is equivalent to 38 per cent linolenic acid. This figure would seem, however, to be entirely too high, since Lewkowitsch[16] found, by determining the ether-insoluble bromides of linseed oil, only 15.4 per cent of linolenic acid.

SAMPLES

The lumbang oil used in this investigation was the ordinary first-grade, raw oil purchased from one of the Chinese oil dealers in Manila. The raw linseed oil was obtained from one of the drug companies in Manila. Data on these samples are given in Table 2.

TABLE 2.—*Constants of lumbang and linseed (raw) oils.*

Constants.	Lumbang oil	Linseed oil.
Specific gravity	0.92292 $\left(\frac{27.4^{\circ}}{4^{\circ}}\right)$	0.92576 $\left(\frac{28.4^{\circ}}{4^{\circ}}\right.$
Refractive index (Abbé)	1.4733 (33.1°)	1.4788 (26.3°)
Iodine value (Hübl)	144.6	165.5
Surface tension (Dynes)	36.9	35.3

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[12] West, A. P., and Montes, Z., Philip. Journ. Sci. **18** (1921) 630.

[13] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes **1** (1921) 556.

[14] Op. cit. 585.

[15] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes **2** (1914) 62.

[16] Op. cit. 60.

PROCEDURE

In carrying out the oxidation experiments a measured quantity of dried air was passed through a small gas wash bottle containing lumbang oil which was heated in a bath to a temperature of 75°. The excess of air which passed through the oil was then conducted through various absorption tubes. At stated intervals the oxidation was discontinued temporarily and the amount of oxygen that reacted with the oil was determined by weighing the vessel containing the oil and the tubes which absorbed the gases escaping from the oil. For comparative data we treated linseed oil in the same manner and used the same gas wash bottle that was employed for determining the oxygen absorption of lumbang oil. Samples of lumbang oil were also oxidized in the same manner for definite periods of time after which the oxidized samples were analyzed. The results of the changes in lumbang oil caused by slow oxidation were calculated from the data thus obtained.

The air used for oxidation was obtained from a large sulphuric acid carboy by allowing a current of water to enter through a tube reaching to the bottom, the air being expelled from the top of the carboy as the water gradually rose. The air was then passed through a Drechsel wash bottle containing sulphuric acid and then through three soda lime tubes and one calcium chloride tube, after which it entered the oil. After the current of air had passed through the oil it was allowed to flow through two small wash bottles containing concentrated sulphuric acid, a tube containing solid potassium hydroxide, three soda lime tubes, and two calcium chloride tubes. Two carboys were used for generating the supply of air. The water used for expelling the air from the carboys was obtained from a constant level tank placed above the carboys and the flow of water was controlled by means of a two-way stopcock. Each carboy was calibrated and had a graduated scale attached to indicate the approximate volume of air entering the oil.

The bath, in which the weighed vessel containing the lumbang oil was immersed, was stirred by a hot-air motor and the temperature was controlled accurately at 75° by a thermo regulator. The bath was covered during the periods of oxidation, so as to prevent the access of light and thus eliminate the influence of this variable factor which, as Genthe[17] showed, accelerates the oxidation reaction.

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[17] Genthe A., Zeits. für Angew. Chem. 19 (1906) 2090.

The entire oxidation apparatus is illustrated by photographs, here reproduced as Plate 1.

RESULTS

When linseed oil is blown, not only is oxygen absorbed by the oil forming nonvolatile products, as in drying, but a portion of the oil reacts with oxygen to form volatile products which escape. Lumbang oil behaves in a similar manner when blown. These drying oils, therefore, not only tend to gain in weight due to absorbed oxygen (apparent oxygen absorption), but also tend to decrease in weight due to escaping volatile products. The total amount of oxygen which gradually reacts with the constituents in the oil during the blowing process may be determined by weighing the vessel containing the oil and the tubes which absorb the gases escaping from the oil.[18] Data showing the apparent oxygen absorption, volatile products evolved, and the total oxygen absorption of lumbang oil blown for one hundred hours at 75° are given in Table 3. For comparison we treated linseed oil in the same manner and the data are given in Table 4.

TABLE 3.—*Oxygen absorption of lumbang oil blown for various periods at 75°.*

[Weight of oil used, 44.8633 grams.]

Period blown.	Approximate volume of air used.	Increase in weight of oil (apparent oxygen absorption).		Weight of volatile products.		Total oxygen absorption.	
Hours.	*Liters.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*
10	212	0.2113	0.47	0.2006	0.45	0.4119	0.92
20	423	0.7132	1.59	0.4379	0.98	1.1511	2.57
30	634	1.0567	2.35	0.8075	1.80	1.8642	4.15
40	839	1.3048	2.96	1.0656	2.32	2.3704	5.28
60	1,260	1.7258	3.85	1.7103	3.81	3.4361	7.66
80	1,673	2.0132	4.49	2.3727	5.29	4.3859	9.78
100	2,099	2.1168	4.72	3.0600	6.82	5.1768	11.54

The data given in Tables 3 and 4 show that in the early stages of oxidation (blowing) the percentage of apparent oxygen absorption, volatile products evolved, and total oxygen absorption are greater for lumbang than for linseed oil. These figures are cumulative; that is, the figure 4.15 (Table 3) represents the total percentage of oxygen absorption of lumbang oil blown for thirty hours. As the oxidation process continues the velocity of oxygen absorption increases more rapidly for linseed than for lumbang oil until at one hundred hours the percentage of total oxygen absorption of linseed is greater than that of lumbang.

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[18] Friend, J. N., The Chemistry of Linseed Oil (1917) 48.

TABLE 4.—*Oxygen absorption of linseed oil blown for various periods at 75°.*

[Weight of oil used, 45.1078 grams.]

Period blown.	Approximate volume of air used.	Increase in weight of oil (apparent oxygen absorption).		Weight of volatile products.		Total oxygen absorption.	
Hours.	*Liters.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*	*Grams.*	*Per cent.*
10	212	−0.0130	0.03	0.1130	0.25	0.1000	0.22
30	634	−0.0132	0.03	0.5931	1.32	0.5799	1.29
40	839	0.3106	0.69	0.8421	1.87	1.1527	2.56
60	1,260	0.9224	2.04	1.4587	3.24	2.3811	5.28
80	1,673	1.4170	3.14	2.2767	5.05	3.6937	8.19
100	2,099	2.0798	4.61	3.4821	7.72	5.5619	12.33

TABLE 5.—*Total percentage of oxygen absorption per hour during different periods in the oxidation of lumbang and linseed oils blown at 75°.*

Period.	Lumbang oil.	Linseed oil.
Hours.	*Per cent.*	*Per cent.*
0 to 10	0.092	0.022
10 to 30	0.161	0.053
30 to 40	0.113	0.127
40 to 60	0.119	0.136
60 to 80	0.106	0.145
80 to 100	0.088	0.207

Data showing a comparison of the relative velocity of oxygen absorption of lumbang and linseed oils are given in Table 5. These figures, giving the total percentage of oxygen absorption per hour during definite periods of time, indicate that for about the first thirty hours lumbang oil absorbs oxygen much more rapidly than does linseed oil. After thirty hours of oxidation the absorption velocity of lumbang gradually decreases while there is a very considerable increase in the absorption velocity of linseed. Both oils have approximately the same absorption velocity for the period of oxidation extending from about thirty to forty hours. With linseed oil, the velocity of oxygen absorption increases continually up to a period of one hundred hours at which time the oxidation experiments were discontinued.

Analyses of lumbang and linseed oils, given in Table 1, show that both oils consist of a mixture of unsaturated glycerides (linolenic, linolic, and oleic) and contain also glycerides of saturated acids. Linseed oil contains a much larger percentage of linolenic glyceride and also of the saturated glycerides than does lumbang oil. The saturated glycerides have no particular drying power and are generally regarded as undesirable constituents in drying oils. Perhaps the saturated glycerides exert a retarding influence and, since lumbang contains a much smaller proportion of saturated glycerides (retarders) than does linseed, the velocity of oxygen absorption in the early stages of oxidation is therefore much greater for lumbang than for linseed.

With linseed oil the velocity of oxygen absorption is very slow for about the first thirty hours, due possibly to the retarding influence of the saturated glycerides, and after that time the absorption velocity increases considerably. It may be, as some authorities believe, that in the early stages of oxidation autocatalysts are formed and these substances accelerate the absorption velocity. Linseed oil contains a considerable quantity of linolenic glyceride which, as will be shown later, absorbs oxygen much more readily than does either linolic or oleic glyceride. Possibly after about thirty hours of oxidation a sufficient quantity of autocatalysts has accumulated to overcome the retarding influence of the saturated glycerides as well as to exert a marked autocatalytic influence on the absorption velocity of the unsaturated glycerides, particularly the highly unsaturated linolenic glyceride.

Perhaps autocatalysts are formed in both lumbang and linseed oils. The autocatalyst, if present, in lumbang oil may be effective for the first thirty hours because no considerable quantity of saturated glycerides (retarders) is present. Lumbang oil contains only 6.5 per cent of linolenic glyceride, which is the most active absorber of oxygen. As shown later, a considerable proportion of this is oxidized during the first thirty hours of oxidation and after that time the quantity of linolenic glyceride that remains is probably so small that the oxidation of this particular glyceride does not produce a very marked effect upon the oxidation of the entire oil. Although the autocatalysts may still tend to accelerate the oxygen absorption of linolic and oleic glycerides, these substances naturally absorb oxygen much more slowly than does linolenic glyceride and, perhaps, the effect of these compounds on the total oxygen absorption of the oil is not sufficient to increase the rate of total oxygen absorption after thirty hours. The result is that the figures showing the percentage oxygen absorption per hour (Table 5) of lumbang oil increase up to thirty hours due, perhaps, to autocatalysis and the absence of retarders, and after that they decrease due, possibly, to an insufficiency of linolenic glyceride and also to the slow absorption of oxygen by linolic and oleic glycerides.

CONSTANTS OF OXIDIZED OILS

Constants of samples of lumbang and linseed oils blown for various periods of time at 75° are given in Table 6. The iodine values were determined by means of the Hübl method. Surface-tension measurements were made with the Du Nouy surface-tension apparatus. As shown by the data both lumbang and linseed oils gave very similar results. By continued blowing the surface-tension and refractive index (Abbé) of both oils increased slightly, while the iodine values of both oils decreased considerably.

TABLE 6.—*Iodine value, refractive index (Abbé), and surface tension (Du Nouy) of lumbang and linseed oils blown at 75°.*

Period blown.	Approximate volume of air used.	Iodine value (Hübl).		Surface tension at 28°.	
		Linseed oil.	Lumbang oil.	Linseed oil.	Lumbang oil.
Hours.	*Liters.*			*Dynes.*	*Dynes.*
0	0	165.5	144.6	35.3	36.9
20	400	160.5	133.1	36.7	37.6
40	781	142.6	119.1	37.4	38.0
60	1,276	122.6	102.4	38.2	38.4
80	1,652	109.1	91.1	38.8	38.7

Period blown.	Approximate volume of air used.	Refractive index (Abbé).			
		Lumbang oil.		Linseed oil.	
		Temperature.	Refractive index.	Temperature.	Refractive index.
Hours.	*Liters.*	*°C.*		*°C.*	
0	0	33.1	1.4733	26.3	1.4788
20	400	32	1.4750	26.4	1.4796
40	781	32	1.4769	26.3	1.4821
60	1,276	32	1.4788	26.4	1.4844
80	1,652	32	1.4800	26.4	1.4858

ANALYSIS OF OXIDIZED OILS

To ascertain the relative oxidation of the various unsaturated compounds in lumbang oil, samples of the oil were oxidized for definite periods of time and the composition of the unoxidized portion of the oxidized samples was determined by analysis. The analytical procedure consisted in converting the oxidized glycerides into their corresponding oxidized acids, separating the oxidized acids by a modification of Fahrion's method,[19] and determining the proportions of unoxidized linolenic, linolic, and oleic acids by means of the bromo-derivative method.[20]

In separating the oxidized acids by a modification of Fahrion's method the oxidized oil was saponified in the usual manner and the alcohol eliminated by distilling. The resulting soaps were then decomposed by dilute hydrochloric acid and the total acids extracted twice with ether. The ethereal solution was dehydrated with anhydrous sodium sulphate, filtered, and the ether was removed by distillation. The total acids were then heated (reflux) for an hour with about 200 cubic centimeters of petroleum ether (boiling point, 35° to 50°), cooled, and the mixture treated with anhydrous sodium sulphate which facilitates the precipitation of colloidal oxyacids. The mixture was then shaken thoroughly and allowed to stand about two hours. The oxyacids, which had a brown, sticky, jellylike appearance, adhered to the sides of the flask. The mixture was filtered and the filter paper returned to the flask containing the sticky oxyacids. The oxyacids were then dissolved in ether, the ethereal solution was filtered into a weighed flask, and the ether eliminated by distillation.

The petroleum ether solution containing the unoxidized acids was transferred to a weighed flask, and the unoxidized acids were separated from the solvent by distilling.

Samples of lumbang oil oxidized for various periods of time were analyzed according to this modification of Fahrion's method. The results are recorded in Table 7.

When lumbang oil is oxidized the percentage of oxidized glycerides increases while the percentage of unoxidized (unsaturated) glycerides decreases. This fact is brought out very clearly by the data given in Table 7, which show that the percentage of oxidized acids, corresponding to the oxdized glycerides, gradually increases while the percentage of unoxidized (unsaturated) acids, corresponding to the unsaturated glycerides, decreases. The results show, approximately, the relative proportions of oxidized and unoxidized constituents in lumbang oil blown for various periods of time.

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[19] Lewkowitsch, J., Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 593.

[20] Op. cit. 585.

TABLE 7.—*Separation of oxidized and unoxidized (unsaturated) acids from lumbang oil blown at 75° by Fahrion's method, modified.*

Sample No.	Period blown.	Approximate volume of air used.	Oxidized acids.	Unoxidized (unsaturated) acids.	Total acids.
	Hours.	*Liters.*	*Per cent.*	*Per cent.*	*Per cent.*
1[a]	0		2.73	93.04	95.77
2	20	400	7.13	88.52	95.65
3	40	781	17.46	79.07	96.53
4	60	1,276	26.86	68.66	95.52
5	80	1,652	32.24	62.12	94.36

[a] The acids in this sample were separated by the lead-salt method.—West and Montes, Philip. Journ. Sci. 18 (1921) 625.

UNOXIDIZED (UNSATURATED) ACIDS

Samples of unoxidized (unsaturated) acids separated by a modification of Fahrion's method were analyzed by the bromoderivative method, which is used to separate the various unsaturated acids from each other. The bromine addition products of the unsaturated acids were prepared by dissolving a portion of the unsaturated acids in ether; the ethereal solution was cooled to a temperature of —10° and bromine was added slowly, after which the solution was allowed to stand about three hours at —10°. The crystals of linolenic hexabromide thus obtained were filtered through a weighed filter paper. The filtrate from the hexabromide was shaken in a separating funnel with 10 per cent sodium thiosulphate solution to remove the excess bromine, after which the separated ethereal solution was dehydrated with anhydrous sodium sulphate, filtered, and distilled to eliminate the ether. The residue that remained was then treated with petroleum ether (boiling point, 35° to 50°) and the mixture heated (reflux) about one hour. The mixture was then cooled, and the crystals of linolic tetrabromide were separated by filtration. By concentrating the petroleum ether filtrate to a volume of about 150 cubic centimeters and allowing the solution to stand overnight, a second crop of tetrabromide crystals was obtained.

The petroleum ether filtrate from the crystalline linolic tetrabromide was concentrated to a volume of about 100 cubic centimeters, transferred to a small distilling flask which had been previously weighed, and the solution distilled in vacuum until no more petroleum ether passed over. The dark residue thus obtained was then weighed and the bromine content determined. The bromine content of linolic tetrabromide is 53.33 per cent; and of oleic dibromide, 36.18 per cent. Knowing the bromide content of the residue, the percentages of linolic tetrabromide and of oleic dibromide can be calculated readily.

The results of analyzing the unoxidized (unsaturated) acids separated from samples of lumbang oil blown for twenty and sixty hours are given in Tables 8 and 9, respectively.

Lumbang oil blown for twenty hours, when analyzed by a modification of Fahrion's method, gave 7.13 per cent of oxidized acids and 88.52 per cent of unoxidized (unsaturated) acids. When blown for sixty hours, analysis of the oil gave 26.86 per cent oxidized acids and 68.66 per cent unoxidized (unsaturated) acids (Table 7). The unsaturated acids, when analyzed by the bromo-derivative method and the results calculated as glycerides originally present in the oil, gave the data recorded in the last column of Tables 8 and 9, and also in Table 10. The oxidized

TABLE 8.—*Analysis of unoxidized (unsaturated) acids separated from lumbang oil which was blown for twenty hours at 75° (bromo-derivative method).*

	Grams.
Sample of liquid acids	2.0308
Hexabromide (ether-insoluble bromide)	0.3080
First crop of tetrabromide	0.0216
Second crop of tetrabromide	0.3062
Residue (dibromide and tetrabromide; bromine content, 42.66 per cent)	3.0788
Dibromide in residue	1.9150
Tetrabromide in residue	1.1640
Total tetrabromide found	1.4918
Linolenic acid equivalent to hexabromide	0.1131
Linolic acid equivalent to tetrabromide	0.6963
Oleic acid equivalent to dibromide	1.2220

CALCULATION OF UNSATURATED ACIDS TO GLYCERIDES ORIGINALLY PRESENT IN THE OIL.

Acid.	Mixture of unsaturated acids.	Unsaturated calculated on basis of original oil.	Unsaturated glycerides in original oil.
	Per cent.	*Per cent.*	*Per cent.*
Linolenic	5.56	4.92	5.14
Linolic	34.28	30.34	31.71
Oleic	60.15	53.24	55.64

acids, separated by Fahrion's method (Table 7), were calculated as glycerides by using the factor 1.04, which is the factor for converting oxylinolic acid to oxylinolic glyceride. The results are recorded in Table 10.

TABLE 9.—*Analysis of unoxidized (unsaturated) acids separated from lumbang oil which was blown for sixty hours at 75° (bromo-derivative method).*

	Grams.
Sample of liquid acids	3.3088
Hexabromide (ether-insoluble bromide)	0.1242
First crop of tetrabromide	0.0754
Second crop of tetrabromide	0.3430
Residue (dibromide and tetrabromide; bromine content 41.78 per cent)	5.1512
Dibromide in residue	3.4690
Tetrabromide in residue	1.6822
Total tetrabromide found	2.1006
Linolenic acid equivalent to hexabromide	0.0455
Linolic acid equivalent to tetrabromide	0.9805
Oleic acid equivalent to dibromide	2.2130

CALCULATION OF UNSATURATED ACIDS TO GLYCERIDES ORIGINALLY PRESENT IN THE OIL.

Acid.	Mixture of unsaturated acids.	Unsaturated acids calculated on basis of original oil.	Unsaturated glycerides in original oil.
	Per cent.	*Per cent.*	*Per cent.*
Linolenic	1.38	0.95	0.99
Linolic	29.63	20.35	21.27
Oleic	66.89	45.93	48.00

TABLE 10.—*Composition of raw and blown lumbang oil.*[a]

Constituent.	Raw oil.	Oil blown for twenty hours.	Oil blown for sixty hours.
Unsaturated glycerides:	*Per cent.*	*Per cent.*	*Per cent.*
Linolenic	6.5	5.1	1.0
Linolic	33.5	31.7	21.3
Oleic	57.0	55.6	48.0
Oxidized glycerides	2.8	7.4	27.9
Total	99.8	99.8	98.2

[a] The composition of the raw oil was determined by West and Montes, Philip. Journ. Sci. 18 (1921) 633. The temperature of blowing was 75°.

The results given in Table 10 show that when lumbang oil is blown (oxidized) for various periods of time the percentage of oxidized glycerides increases while the percentage of unsaturated glycerides (linolenic, linolic, and oleic) decreases.

TABLE 11.—*Percentage of unsaturated glycerides (linolenic, linolic, and oleic) oxidized during different periods at 75° and the percentage of these glycerides oxidized per hour during these periods.*

Glyceride.	Proportion of glyceride oxidized.			Percentage of glyceride oxidized per hour.	
	Period, 0 to 20 hours.	Period, 20 to 60 hours.	Period, 0 to 60 hours.	Period, 0 to 20 hours.	Period, 20 to 60 hours.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Linolenic	21.5	63.1	84.6	1.07	1.58
Linolic	5.4	31.0	36.4	0.27	0.77
Oleic	2.5	13.3	15.8	0.12	0.33

In Table 11 is given the percentage of unsaturated glycerides (linolenic, linolic, and oleic) oxidized during different periods of time. The data show that the more unsaturated glyceride is oxidized more readily than is the less unsaturated. This is what one would naturally expect if absorption of oxygen takes place at the double bonds and we assume that the formula of linolenic glyceride has nine double bonds; linolic glyceride, six double bonds; and oleic glyceride, only three double bonds.

Figures giving the percentage of each glyceride oxidized per hour (Table 11) show that the rate of oxidation (1.58 per cent) of linolenic glyceride for the period extending from twenty to sixty hours is less than double the rate (1.07 per cent) for the first twenty hours. Figures for linolic and oleic glycerides show that the rate of oxidation for the period extending from twenty to sixty hours is about three times the rate for the first twenty hours. These results would seem to indicate that, although the rate of oxidation of linolenic glyceride increases after twenty hours of oxidation, it does not increase as much as the oxidation rates of linolic and oleic glycerides. Since there is such a small percentage of linolenic glyceride in lumbang oil and as a considerable proportion of this is oxidized during the early stages of oxidation, possibly the increase in the rate of oxidation during the later stages is not as great as it would normally be if the oil contained more linolenic glyceride.

We have not as yet endeavored to get any data regarding the constitution of the oxidized compounds in blown lumbang oil or the compounds that are present in the volatile products. We expect to make investigations along these lines when time permits.

SUMMARY

When lumbang and linseed oils are blown under the same conditions at 75° the percentage of apparent oxygen absorption, volatile products evolved, and total oxygen absorption in the early stages of oxidation (blowing) are greater for lumbang than for linseed oil (Tables 3 and 4). As the oxidation process continues the velocity of oxygen absorption increases more rapidly for linseed than for lumbang oil until at one hundred hours the percentage of total oxygen absorption of linseed is greater than that of lumbang.

Data giving the total percentage of oxygen absorption per hour during definite periods of time, for lumbang and linseed oils (Table 5), indicate that for about the first thirty hours lumbang oil absorbs oxygen much more rapidly than does linseed oil. After thirty hours of oxidation the absorption velocity of lumbang gradually decreases while there is a very considerable increase in the absorption velocity of linseed. Both oils have approximately the same absorption velocity for the period of oxidation extending from about thirty to forty hours. With linseed oil, the velocity of oxygen absorption increases continually up to a period of one hundred hours at which time the oxidation experiments were discontinued.

Both linseed and lumbang oils consist of a mixture of unsaturated glycerides (linolenic, linolic, and oleic) and contain also saturated glycerides. Linseed oil contains a much larger percentage of linolenic glyceride and also the saturated glycerides than does lumbang. Possibly autocatalysts are formed in both lumbang and linseed oils and these substances tend to accelerate the velocity of oxygen absorption while the saturated glycerides that are present in these oils tend to retard the absorption velocity. Since lumbang oil contains a much smaller proportion of saturated glycerides (retarders) than does linseed oil, the velocity of oxygen absorption in the early stages of oxidation is much greater for lumbang than for linseed. With linseed oil, perhaps a sufficient quantity of autocatalysts accumulates, after thirty hours of oxidation, to overcome the retarding influence of the saturated glycerides and to exert a marked autocatalytic influence on the absorption velocity of the unsaturated glycerides, particularly the highly unsaturated linolenic glyceride. As a result, the figures showing the oxygen absorption velocity per hour (Table 5) of linseed oil increase considerably after thirty hours of oxidation.

Constants of samples of lumbang and linseed oils blown for various periods of time at 75° were determined. Both oils gave very similar results. By continued blowing the surface-tension and refractive index of both oils increased slightly while the iodine values of both oils decreased considerably.

Samples of lumbang oil oxidized for various periods of time were analyzed. The results showed that the percentage of oxidized glycerides increased while the percentage of unoxidized (unsaturated) glycerides decreased. The data also showed the relative oxidation of the various unsaturated glycerides in lumbang oil; linolenic glyceride was oxidized more readily than was linolic, and the latter was oxidized more readily than was oleic. If it is true that, in drying or blowing, absorption of oxygen takes place at the double bonds, then the more unsaturated the compound the more readily it should absorb oxygen. The experimental data obtained accord well with the formulas which have been suggested for these unsaturated glycerides that are contained in lumbang oil since linolenic glyceride is more unsaturated than linolic glyceride which, in turn, is more unsaturated than oleic glyceride.

We wish to express our thanks and appreciation to Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry, for the material used in this investigation and the assistance he has kindly given.

ILLUSTRATION

PLATE 1

FIG. 1. Apparatus used for oxidation of oils, front view.
. 2. Apparatus used for oxidation of oils, side view.

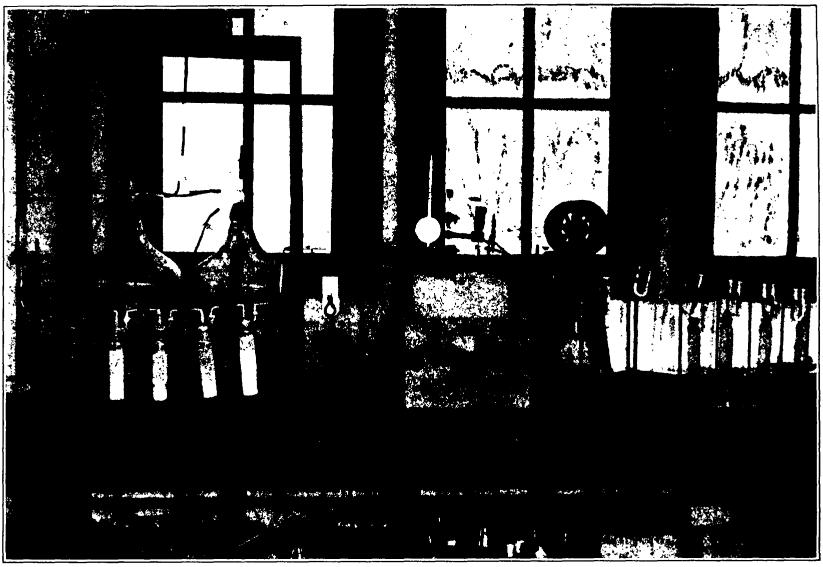

Fig. 1. Front view.

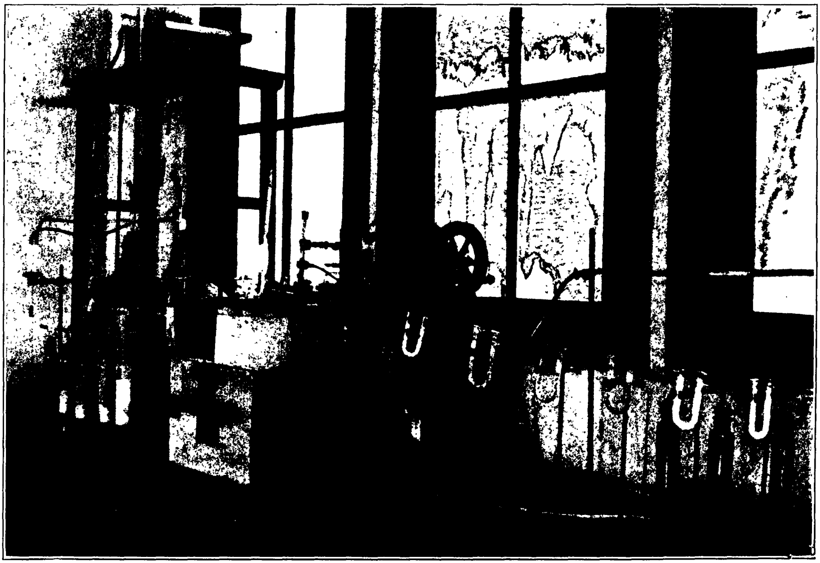

Fig. 2. Side view.

PLATE 1. APPARATUS USED FOR OXIDATION OF OILS.

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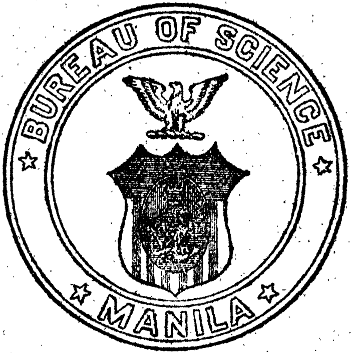

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STUDIES ON THE EMBRYOGENY AND POSTNATAL DEVELOPMENT OF THE APHIDIDÆ WITH SPECIAL REFERENCE TO THE HISTORY OF THE "SYMBIOTIC ORGAN," OR "MYCETOM"[1]

By LEOPOLDO B. UICHANCO

Of the College of Agriculture, University of the Philippines
Los Baños

THIRTEEN PLATES

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[1] Contribution from the entomological laboratories of the Bussey Institution, Harvard University, No. 202. Received for publication May 17, 1922. The Bussey Institution and the University of the Philippines have contributed funds covering a large part of the cost of making the halftone plates for this paper.

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INTRODUCTION

The Aphididæ have attracted the attention of naturalists for a long time, on account of their economic importance as pests of many cultivated plants, their peculiar method of reproduction, and other interesting habits. It is unfortunate however that, as Baker (1920) has recently pointed out, taxonomic studies on this family have not kept pace with the anatomical and the biologic, with the result that many of the earlier investigators have used species of doubtful identity, which fact makes adequate comparison and correlation of results obtained by different workers impracticable in a number of cases. This difficult condition had been noted years ago by Stevens (1906). It is encouraging to note however that, since her time, a few very able and enthusiastic systematists, principally in America and in Europe, have interested themselves in working out a more comprehensive classification of aphids.

In the field of aphid embryology, the more important papers bearing on the subject, particularly on the parthenogenetic form, are products of the past century. These publications are in general models of care and skill in preparation. They have furnished an important and very useful working basis for subsequent investigators.

The present work is an attempt to gather additional data on the embryonic and postembryonic development of aphids. The investigation has been almost exclusively confined to parthenogenetic individuals; but I am hoping to be able to make a more extensive study of the amphigonous material in the future, as time and opportunity permit. Particular effort is made in the present work to study the ontogenetic cycle of the peculiar granular inclusions in certain specialized cells, which are known as mycetocytes. These granular bodies are believed to be microorganisms of a symbiotic nature. The organs harboring these supposed microörganisms, which have been given the name mycetom (Šulc, 1910), have a very interesting history. An attempt is made in the present work to follow their early formation and subsequent development.

Preliminary work was done on the problem in the fall of 1919, at the suggestion of Prof. W. M. Wheeler, under whose direction the present investigation was carried on. I take this opportunity to express to him my thanks for encouragement and helpful advice during the progress of the work, and also for generous loan of important pamphlets from his private library. Grateful acknowledgment is likewise due to Prof. C. T. Brues and to other members of the staff of the Bussey Institution, upon whom I have called for assistance, both scientific and technical, from time to time.

HISTORICAL

The literature bearing on aphid reproduction, embryology, parthenogenesis, and symbiosis is very extensive. Some very careful historical discussion along these lines has been published from time to time; but there appears to be some justification for preparing another review in that the previous ones only partially cover their respective fields. Further, these older treatises are scattered in different publications, some of which are not easily accessible. In the preparation of the present review, the papers of the following authors have been frequently consulted: Buckton (1876); Taschenberg (1892); Phillips (1903); Berlese (1909, pp. 5-29); Šulc (1910); and Buchner (1912, 1921).

REVIEW OF THE LITERATURE ON REPRODUCTION AND PARTHENOGENETIC EMBRYOLOGY IN APHIDS

The first observer to publish on aphids appears to be Leeuwenhoek (1695). In his Epistola 90 he records the viviparous production of several species of aphids, principally the one on *Ribes* sp. His inability to discover any male led him to believe that the viviparous young are produced by hermaphroditic individuals. About fifty years later, Réaumur (1737) noted the same method of unisexual reproduction. He was so blinded, however, by his belief that the union of biparental elements is necessary as a prerequisite to development of the embryo, that he insisted that the males had to be present, in spite of the fact that he himself had failed to discover any, and that copulation had had to take place.

It was not until Bonnet (1745), then a twenty-year-old youth, a student of Réaumur, undertook to raise nine consecutive viviparous generations in two and one-half months that it was proved, for the first time, that the male is dispensed with in this method of reproduction. The same investigator further observed, also for the first time, that in the case of oak aphids males are present and are in copula with the females, the latter, however, laying eggs instead of bearing their young "alive." He, nevertheless, failed either to grasp the significance of this occurrence of amphigonous generation or to notice that this oviparous form is an entirely distinct individual from the viviparous.

To de Geer (1771) belongs the credit of being the first to discover that an oviparous individual is always oviparous, and a viviparous always viviparous. His observations on "*Lachnus pini*" [2] and on "*Aphis rosæ*" led him to the conclusions that, of these species of aphids, viviparous individuals are found during the summer and that oviparous forms are present only in the fall. He ventured further to predict, on the basis of his studies, that, if aphids were to be discovered in the Tropics (practically nothing was known at that time about tropical aphids), they would be exclusively viviparous. He did not, however, note the relationship of the oviparous and the viviparous generations in that they alternate with each other in the yearly cycle of generations.

The first extensive experiments on viviparous reproduction were performed by Kyber (1815). He succeeded in raising for a period of four years consecutive viviparous generations of "*Aphis rosæ*." As I have noted in an earlier paper (Uichanco, 1921), it is quite probable that Kyber secured his experimental material from among a strain that normally reproduces exclusively by parthenogenesis.

Duvau (1825) succeeded in raising eleven continuous viviparous generations for a period of seven months, at the end of which time he noted that oviparous generation occurs. He was thus enabled to prove experimentally, for the first time, that the viviparous and the oviparous individuals are entirely distinct and irreversible forms, and that one of these generations in turn gives rise to the other. His views were confirmed by Morren (1836), who further advanced the theory that the young viviparously produced aphid develops in the body of the parent by individualization of a previously organized tissue; by Ratzeburg (1844); and by von Heyden (1857), who claimed to have seen oviparous females actually copulate with males.

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[2] Unverified or unverifiable determinations are reported in the present paper in quotation marks.

Duvau's conclusions were further strengthened by the findings of von Siebold (1839), who discovered for the first time in connection with aphids that oviparous individuals of "*Aphis loniceræ*" have a seminal receptacle, while the viviparous ones are devoid of this organ. He also noted that there is a difference in the early developmental history between a viviparous and an oviparous generation.

The views of Duvau were elaborated later by Steenstrup (1842), when the latter introduced the idea of alternation of generations in aphid reproduction. Steenstrup considered the viviparous mother not as female, but as nurse which is devoid of ovaries but which possesses a well-developed uterus. The viviparous young, according to him, arises through a process of budding.

Steenstrup's view found a supporter in the United States in Burnett (1853), who claimed that reproduction in viviparous aphids is a case of gemmiparity. He also failed to discover in these forms true ovaries.

Leydig (1848) arrived at entirely different conclusions. He pointed out that the viviparous embryos, like the oviparous, arise from eggs and are not produced by budding. He further noted that there was no observable difference between the viviparous and the oviparous eggs, except in the relative amount of yolk. In a later publication (Leydig, 1850), he reiterated his former views, and disproved Carus's (1849, p. 20) contention, published the year before, that the young of viviparous aphids arise from an amorphous central mass, in contradistinction to the cellular nature of the egg of oviparous individuals, the former being analogous to the "Keimschlauchen" of certain trematodes. It may be noted in this connection that in his last-cited paper, Leydig (1850) states that he saw the organs that we now know as "pseudovitellus," "mycetom," "green body," and "symbiotic organs," of which he wrote a recognizable description.

The questions as to whether or not the viviparous individuals are true females and the viviparously produced embryos arise from true eggs remained unsettled for many years. Even in the present day we still find a few authors who, influenced perhaps by the earlier views, have referred to this method of reproduction as "asexual." Von Siebold (1856) and Leuckart (1858) were among the best known of the earlier supporters of the asexuality of the viviparous aphids, as previously announced by Steenstrup and by Carus. Huxley (1858) and Lubbock (1859) were somewhat noncommittal in their statements in regard to this point, but they, too, were obviously influenced by the old idea that fertilization is the only criterion of sexual reproduction so that they named the eggs formed in the ovaries of viviparous mothers "pseudova," as distinguished from the ova of the oviparous individuals, which they seemed to think were the only true ova. Among the opponents of such views during those times were Filippi (1856, p. 44) and Claus (1858), both of whom maintained that the viviparous forms are true females.

To Huxley (1858) belongs the credit of being the first to recognize the fact that viviparous reproduction in aphids is a true case of parthenogenesis, in the sense in which we use the word to-day.

Owen (1849) had previously used the same term, meaning however an alternation of generations, according to the idea of Steenstrup, the former further elaborating the latter's views in suggesting that copulation which takes place in the fall furnishes the "fertilizing influence," or "spermatic force," sufficient to bring about the development of the succeeding spring and summer generations. From his description (pp. 69 and 70) it appears that he had reference to the "symbiotic organs" when he spoke of "spermatic force."

Claus (1864) seconded Huxley's contention by stating that "die Keime der viviparen Blattläuse sind Eier, die sich parthenogenetisch entwickeln." The next important step in the advancement of our knowledge of parthenogenetic reproduction in aphids is the discovery by Blochmann (1887) that, while the amphigonous ovum extrudes two polar bodies, the parthenogenetic produces only one.

The later development of the parthenogenetic embryo of aphids was apparently first studied extensively by Huxley (1858), and reported in the paper which I have just cited.

In the same year Leuckart (1858), in a general treatise on insect reproduction, noted the fact that he could find no fundamental difference between the ontogeny of the parthenogenetic embryo and that of the amphigonous embryo, except that the former develops very early within the body of the mother.

A year later Lubbock (1859) published his paper on the ova and pseudova of insects, in which the part dealing with aphid reproduction is merely confirmatory of Huxley's observations.

The next important paper was that of Metschnikow[3] (1866), who took up the embryology of parthenogenetic aphids in much greater detail than any of his predecessors. Considering that at the time this paper was published Metschnikow was only twenty-one years of age, one cannot but admire the remarkable thoroughness with which this brilliant Russian genius attempted to treat a subject that in those days had been very little investigated.

Brandt (1869) noted for the first time the phenomenon of rotation (*Umklappung*) of the aphid embryo, as well as that of certain Heteroptera and Libellulidæ, thus antedating by many years the observations which Hallez (1886) subsequently formulated into a *"loi de l'orientation de l'embryon chez les insectes,"* now bearing the latter's name.

In the same year Balbiani (1869, 1870, 1870a, 1871, 1871a) began the publication, on instalments, of his *Mémoire,* which contains many interesting views on aphid embryology. This author was the first to work on the embryogeny of amphigonous aphids.

Brass (1883), Will (1883, 1889), and Witlaczil (1884) complete the list of the more important workers on aphid embryogeny during the past century. In his later paper Will had the advantage over his predecessors in that he was able to study aphid embryos for the first time with the aid of paraffine sections.

Of the more recent workers, it is by no means an easy task to give an adequate and unbiased account; a few of the more important contributors were Stevens (1905, 1906) and Tannreuther (1907), both of whom worked principally on the germ cells and early embryogeny, Hirschler (1912), de Baehr (1920, and also earlier papers), and others.

During the past few years, very creditable embryological papers on Coccidæ and on other Homoptera have also appeared.

REVIEW OF THE LITERATURE ON "SYMBIOSIS" AND ON "SYMBIOTIC ORGANS" IN APHIDS

As I have noted above, Leydig (1850) was the first investigator to publish a description of the symbiotic organs in aphids.

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[3] Also spelled Mecznikow, Metschnikoff, Mečnikov, Metchnikoff, and possibly other variations. These different forms are apparently attempts at rendering into their approximate phonetic equivalents in Roman letters the original Russian characters. The spelling given in the text is adopted in the present paper, being the one used in his article which I cited.

He observed the organ early in the formation of the blastoderm in the parthenogenetic egg as an immigrating

> grüne oder gelbe körnige Masse . . . . . welche anfangs, wie es scheint, frei zwischen den Zellen liegt, später aber deutlich zu grösseren Ballen zusammengehäuft, von einer Membran umschlossen ist und sich an der Bildung der vegetativen Organe der Blattlaus beteiligt.

He did not give the organ any name; although, judging from his discussion, he apparently ascribed to it a nutritive function.

Huxley (1858) studied the formation of this organ which, he noted, appears as a central mass in the parthenogenetic egg; but he apparently overlooked its presence in the amphigonous form. He named the organ, as it occurs in the parthenogenetic ova, "pseudovitellus," since, according to him, "it completely simulates the vitellus of an impregnated [amphigonous] ovum." Lubbock (1859) adopted Huxley's views and name for the organ.

Metschnikow (1866) worked more carefully on the histology and ontogeny of the organ in the viviparous embryo. In that paper, he suggested that the function of the organ is nutritive, calling it "secundäres Dotter," as distinguished from the true, or primary yolk. He noted that the "secundäres Dotter" appears very early in the embryonic history, being found almost simultaneously with the first formation of the anlagen of the genitalia. He gave an account of the origin of the "secundären Dotter" from a large, subglobular, green cell, which in his figures 13 and 17A, Plate 28, is shown as consisting of a large mass of green, coarsely granular cytoplasm and a distinct nucleus and nucleolus. He claimed that this green cell first makes its appearance at the posterior pole of the egg, during the blastodermic formation of the latter, in a swelling which becomes united with the follicular epithelium.

Balbiani (1869, 1870a, 1871) traced the origin of this organ, which he renamed "masse polaire," to a "cellule antipode." The latter probably corresponds to the green cell described by Metschnikow. Balbiani objected to the theory proposed by Huxley, Lubbock, and Metschnikow on the ground that an animal so highly specialized as the aphid would not have yolk persisting throughout its life. Such a view, according to him, was physiological heresy. He revived Leewenhoek's idea of hermaphroditism in aphids, in which he was a strong believer, and suggested that the "masse polaire" is of an androblastic nature. This hypothesis is strikingly suggestive of Owen's (1849) old view, which I have noted above. Balbiani (1869) was the first investigator to report on the presence of the "masse polaire" in the amphigonous generation.

Witlaczil (1882, 1884) traced the origin of the organ in question from the follicular epithelium. He claimed to have seen a direct ingrowth of the latter into the blastocœle, forming thus a club-shaped body which ultimately becomes incorporated as an integral part in the constitution of the embryo. He proposed in his earlier paper (1882) another theory in regard to its function—that it takes the place of the Malpighian tubules which, as previously noted by Schindler (1878), are apparently absent in aphids. However, he gave up this view in his later paper (1884), for then he characterized these organs as being of a doubtful nature. Witlaczil (1882) also noted the presence of *tunica propria,* which envelops the "symbiotic organs."

Will (1889) reaffirmed the old views of Huxley, Lubbock, and Metschnikow that the "secundäre Dotter" is of a nutritive function. He had a very interesting acount of the early history of the formation of this organ, and in many cases his findings have been confirmed by subsequent workers. He noted that the "secundäre Dotter" originate in a thickening of the follicular epithelium toward the posterior pole of the egg, the protoplasm of the epithelial cells in the meantime assuming a

> feinkörnige Beschaffenheit * * * und verwandelt sich in eine Summe feiner Dotterkörnchen, bei deren Bildung die Kerne in Mitleidenschaft gezogen werden und der Atrophie anheimfallen.

He proceeds:

> So findet man bald an der verdickten Stelle des Follikelepithels nur noch eine feinkörnige Dottermasse ohne jede Spur der früher vorhandenen Kerne. Höchstens sind von den letzteren zur Zeit der Dottereinwanderung nur noch spärliche Trümmer in Gestalt zerstreuter Chromatingranula nachzuweisen.

He further questioned the contention of his predecessors to the effect that the formation of the "secundäres Dotter" consists in immigration of certain cells into the egg; for he claimed that only "todte Nahrungsmasse" finds its way into the blastocœle. He did not, however, note the relation of the "vitellophags" with the formation of the "symbiotic organ." He believed that the former represent the entoderm of the aphid embryo, and enter in the formation of the midgut.

Henneguy (1904), with material which he mainly borrowed from an unpublished work of Balbiani, also described the origin of the "pseudovitellus" from the follicular epithelium, as "une celle pediculee epitheliale," which arises by budding.

Flögel (1905) published a carefully written, although somewhat superficial, description of the first appearance of the "pseudovitellus" in the amphigonous eggs of "*Aphis ribis* Linnæus," the relation of this organ to the ovaries, and their subsequent history up to their bipartition as a result of the pressure exerted by the developing alimentary canal. He further noted that, after the birth of the young aphid, the cells of the "pseudovitellus" no longer divide and merely increase in size. Like some of his predecessors, Flögel ascribed to the "pseudovitellus" a nutritive function.

Stevens (1905), in casually mentioning the incursion of the "secondary yolk," spoke of "two conspicuous cells which apparently guard a valvular opening in the wall of the oviduct, and recall the four guard-cells at the inner end of the embryonic pharynx of *Planaria simplicissima.*" She claimed that the "secondary yolk" material enters through this valve.

Tannreuther (1907) reported his inability to find such a valve in the aphids with which he worked. The same investigator claims to have noted the formation of "pseudovitellus" in parthenogenetic eggs, prior to cleavage of the latter, through immigration of certain cells from the follicular epithelium.

Šulc (1910) also reported having observed the presence of the "symbionts" between the egg and the follicular epithelium prior to maturation of the former, inferring therefrom that infection of the egg occurs before cleavage.

A somewhat similar view was held by Hirschler (1912), although his contention was apparently based on no direct evidence of his own.

Buchner (1912, p. 42) published some very interesting accounts of the infection of the winter eggs of aphids by the "symbionts" through a rupture in the follicular epithelium. The "organisms" which have escaped from the "mycetocytes" of the mother enter the developing egg through the opening thus made. He reiterated these views in a later publication (Buchner, 1921). In this book (pp. 211–218) he also gave a unique description of the formation of the "mycetom" in parthenogenetic eggs, with which my findings disagree in a few important particulars. In his text figures 58 and 60, drawn from hitherto unpublished illustrations by one of his students, and in his discussion on pages 212 and 214, he traced the origin of the "mycetom" in the parthenogenetic egg of aphids to a layer of vacuolated cells, which separates from the blastoderm at the posterior pole of the egg, beneath a subglobular mass of cells which he interpreted as the primitive germ cells. He caused this anlage of the "mycetom" eventually to merge with the adjoining portion of the follicular epithelium. In the meantime, according to him, a "mycetom" cell in the cœlomic cavity of the mother forms a connection, through a special process in the epithelium, and in this way, by direct transmission, he fills the formative "mycetom" with "symbionts." The "mycetom" thus formed, he continues, ultimately fills the entire cavity of the blastocœle.

The circumstances which led to the suspicion that granular inclusions in the "mycetocytes" are of a biophytic nature form very interesting history. Blochmann (1886) appears to be the first to recognize the normal presence of intracellular "organisms" in eggs and body tissues of insects. The material he originally worked with consisted of ants and wasps. He noted that bacterialike bodies were present both in the eggs and in the follicular epithelium, and he suspected that they were probably bacteria, although, due to difficulty in working with that material, he very cautiously refrained from committing himself to a definite statement as to their exact nature. He was more confident of his results in his papers published during the following two years (Blochmann, 1887, 1888) for, as he noted, he had found more adequate material for this kind of investigation in "*Periplaneta orientalis*" and "*Blatta germanica.*" As in the ants and wasps he worked with, he also found rod-shaped bodies in the fatty tissue and in the eggs of blattids. His conclusions were more straightforward in the latter case as to the suspicious bacterial nature of these cellular inclusions; he based his contention on their reaction to the various reagents and stains which he used, their multiplication by fission, and their method of infection through the egg. He also attempted to cultivate the "organisms" in beef-peptone-gelatine-agar media, but his results, he reported, were unsatisfactory.

Soon after this author, Wheeler (1889) noted similar bacterialike bodies in the periplasm of *Blattella germanica* Linnæus.

Cholodkowsky (1891) and Heymons (1895, pp. 78, 79) were also among the earlier workers who confirmed Blochmann's observations.

Following the lead of Blochmann, other investigators, influenced either directly or indirectly by his findings, soon took up the subject of "symbiosis" between insects and intracellular "organisms," and the aphids were among the first groups to be worked with. Krassilschtschik (1889, 1890) appears to be the first to work on this family in that connection. His papers were based on investigations on twenty species of aphids. He noted the presence of bacilli which, he suspected, have some relation with the "symbiotic organs." He further noted that "organisms" were located only "entre la couche des cellules adipeuses en dessus et le pseudovitellus en dessous," to the exclusion of all the other organs. He did not recognize the cytoplasmic inclusion of the "mycetocytes" as microörganisms. He termed these bacilluslike bodies "biophytic bacteria," and pointed out that they were not parasites for the reasons that the tissue in which they were found was normal, that they were transmitted directly from one generation to the next, and that they were present in every representative of the species, even in the embryo. He further observed that the development of the mycetom in the embryo began at a very early stage, before the formation of the anlagen of the genitalia which fact, he pointed out, indicated the great importance of this organ in the vital processes of the aphid.

Henneguy (1904), with very little original evidence and drawing mainly from an unpublished work and figures of Balbiani, characterized the green, granular mass which infects the eggs of aphids at an early stage as "microörganisms" and, further, stated that the follicular epithelium, especially the thickened portion which adjoins the posterior pole of the egg, has something to do with the presence of these bodies, for he noted the incursion of the "symbionts" from that source through the gap left by the blastodermal wall.

Pierantoni (1909, 1910, 1911, 1911a) and Šulc (1910), working independently of each other, appear to have been the first to make an effort to prove experimentally that the cytoplasmic inclusions in the "mycetocytes" of aphids are living microorganisms, which are related to the yeasts. The evidence they presented appears to be principally morphological, these bodies resembling the Saccharomycetes in shape and in their method of division by either budding or fission. These authors also worked on other Homoptera. Šulc proposed the name "mycetom" for the organ; and "mycetocyte" for the individual "symbiotic" cell.

Buchner (1912, 1921) published two exhaustive treatises on "symbiosis," not only in aphids, but also in coccids, aleyrodids, psyllids, Cicada, cicadellids, blattids, Hymenoptera, Coleoptera, and Lepidoptera. He gave us a comprehensive review of our present knowledge of "symbiosis" between insects and yeastlike or bacterialike "organisms," in addition to data based on his own work. His observations on the embryonic history of the "symbionts" have already been noted above. He described two species of "symbiotic organisms" in aphids, one of them being, according to him, new to science.

Up to the present time no worker has, to my knowledge, reported a single instance where the intracellular "symbionts" in aphids have been successfully cultivated in artificial media. At least three papers, based on attempts to propagate these "organisms," have been published: One by Pierantoni (1910), who claimed to have obtained colonies and to have observed that many of the organisms multiplied by budding on potato slices; and two later reports by Peklo (1912, 1916) who, likewise, recorded supposedly successful results in inoculation of artificial media, and isolation of pure cultures of the "symbionts" in dilute beef bouillon to which 6 per cent sucrose was added and in agar media made from this solution. Neither of these two authors appears, however, to have furnished adequate evidence to prove the identity of their artificially obtained microörganisms with the "microörganisms" of the aphid "mycetocytes." The difficulty in experiments of this nature appears to lie in at least three causes: (*a*) The microörganisms, if they be such, are probably so specialized in their physiological relations to their host that they cannot live outside the living aphid tissue; (*b*) proper laboratory technic in cultivating these "symbionts," both as to the kind of media used and the manipulation of the organisms, perhaps still remains to be discovered; and (*c*) the difficulty in proving by ordinary bacteriological methods that the organisms obtained in the artificial culture are identical with the cytoplasmic inclusions in the "mycetoms" of aphids, and not contamination from other sources. The last cause is a particularly troublesome obstacle, as I have experienced in my own work during the summer of 1920, in which I succeeded in obtaining yeastlike microörganisms in culture tubes that I had inoculated from various species of aphids, but failed to establish positive proof of their identity with the "symbionts." One method which has been suggested in connection with this work, and which I have not had occasion to use, is to "fish out" individual "microörganisms" with the aid of microdissection apparatus and make direct observations in hanging drops.

As a whole, the assumption that the granular cytoplasmic inclusions of these specialized cells in aphids are symbiotic organisms has been based mainly on indirect evidence. To the morphological proof offered principally by Šulc and by Pierantoni, the following facts may be added: (*a*) As I shall discuss presently, the "symbionts" which are apparently in a quiescent state in the follicular epithelium are at once given a sudden start in their multiplication as soon as the barrier of the dense "Keimhautblastem" disappears at the posterior pole of the egg, thereby bringing the yolk material in contact with them. The granular bodies which are lodged in the follicular epithelium are apparently stimulated by the egg yolk, their rapid multiplication at this time being manifest in the marked swelling of the follicular epithelium near the posterior pole of the egg and the rapid incursion of the "microörganisms" from the former into the latter. This sudden response strongly suggests that these granular inclusions are microörganisms, which begin to grow and divide rapidly as soon as a rich food supply is made available to them. (*b*) Another important peculiarity which leads one to suspect strongly that these inclusions are microorganisms is the marked attraction toward the mass in which they are contained by certain cleavage nuclei, in the earlier stages of the development of the egg. This behavior of certain nuclei or cells of the body proper, as in the case of phagocytosis previously described by Metschnikow (1901),[4] is displayed in the presence of foreign protein.

The basis for the supposition that these "microörganisms" are of a symbiotic nature, as worked out by earlier investigators, has been enumerated by Baumberger (1919, p. 72) and later recast, in a more satisfactory form, by Glaser (1920). I quote from the latter:

> (*a*) Every individual of a species is infected.
>
> (*b*) The infection produces changes in the host cells, but these are harmless.
>
> (*c*) The infection routes and methods of localization, while different in different hosts and symbionts, follow very definite courses within a species.
>
> (*d*) The microörganisms are numerically controlled by the host, never increasing up to a point where they may prove fatal.
>
> (*e*) The microörganisms within the insects obtain nourishment and protection from drastic temperature and drought conditions.

In the case of the coccids, Brues and Glaser (1921) have recently reported that they have succeeded in cultivating the

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[4] This comparison of the behavior of the cleavage nuclei with phagocytosis was suggested to me by Professor Wheeler.

"symbionts" of *Pulvinaria innumerabilis* Rath. In this species there are no specialized "mycetoms" or "mycetocytes," as in the aphids, the supposed microörganisms in the former being found in the adipose tissue. These authors have undertaken to prove the identity of the microörganisms they obtained in their culture media with the coccid "symbionts" by the following criteria: The presence of apparently the same microörganisms in practically all the culture tubes inoculated; the morphological similarity between these microörganisms and the "symbionts" in the body of *Pulvinaria,* and the fact that the former were "recovered in such a large proportion of the cultures," which "left little doubt as to the identity of the two;" and the positive precipitin reaction in the rabbit serum. They have also made a study of the microörganisms they obtained, and noted that they secrete proteolytic, lipolytic, and diastatic enzymes, which, they suggest, may have some relation to their symbiotic nature. It is to be hoped that the work so well begun by these two authors will serve as a stimulus to other investigators in the way of finding a more adequate method of satisfactorily solving the more exact nature of these puzzling bodies in aphids, as well as in other insects.

MATERIAL AND TECHNIC

The material used in the present work was drawn mainly from one species, *Macrosiphum tanaceti* Linnæus. My choice of this aphid was prompted by the fact that during the growing season it is available in great abundance on its host plant, *Tanacetum vulgare* Linnæus (Compositæ), which is a very common weed in the immediate vicinity of the Bussey Institution, thus insuring an adequate supply of specimens. Furthermore, *Macrosiphum* is one of the Aphidinæ,[5] a group which systematists consider, "with the exception of the Mindarinæ, * * * as by far the most primitive" subfamily of the Aphididæ (Baker, 1920). It was believed that by working with a member of this subfamily there would be a better chance to observe characters which might otherwise be modified, obscured, or lost as a result of specialization and that more satisfactory generalized conclusions could thus be reached.

The following species, a large number of which are members of the subfamily Aphidinæ, have also been studied, on a less

[5] Baker (1920) has placed the genus *Macrosiphum* under the subfamily Aphidinæ, tribe Aphidini, subtribe Macrosiphina.

extensive scale, however, in the hope of securing supplementary as well as confirmatory data:

APHIDINÆ[6]

Anoecia corni Fabr.*
Anoecia querci Fitch.*
Lachnus dentatus Le Baron.
Longistigma caryæ Harris.
Drepanaphis acerifolii Thomas.
Drepanosiphum platanoides Schrank.*
Aphis rumicis Linn.*
Macrosiphum œnotheræ Oestlund.
Macrosiphum pisi Kalt.
Macrosiphum rosæ Linn.
Macrosiphum rudbeckiæ Fitch.
Macrosiphum sp. on *Cichorium intibus* Linn. (Compositæ).
Macrosiphum sp. on *Sicyos angulatus* Linn. (Cucurbitaceæ).
Myzus persicæ Sulzer.

ERIOSOMATINÆ

Eriosoma lanigera Hausm.

In addition, unidentified aphids from the following host plants were studied:

Berberis vulgaris Linn. (Berberidaceæ).
Celastrus scandens Linn. (Celastraceæ).
Lythrum salicaria Linn. (Lythraceæ).
Shepherdia (*Elæagnus*) *argentea* Nutt. (Elæagnaceæ).
Solidago virgaurea Linn. (Compositæ).
Viburnum sp. (Caprifoliaceæ).

Biological observations have been made both in the field and in the insectary. For life-history work, each aphid was kept separate on individual food plants by inclosing it with a lamp chimney the top of which was covered with fine muslin. In order to avoid duplications in recording the rate of parturition, the newly born nymphs were destroyed after a count of them had been made.

For a study of aphid embryology, two series are employed; namely, (*a*) fresh material and (*b*) fixed and stained preparations. Examination of fresh material has been found to be essential in the study of the sequence of eggs in the ovarioles and for observations of the normal structure of the ovaries and their contents. Ringer's solution has been employed as dissecting medium. On account of the scarcity of yolk in the parthenogenetic eggs, the constituent parts can be recognized fairly distinctly in the fresh preparations under the microscope until the later part of the blastoderm stage. In *Macrosiphum tanaceti* the green color of the mass of "symbiotic organisms" makes the formative mycetom stand out prominently in contrast with the rest of the egg, which is pale yellowish transparent, thus enabling the observer to trace the general behavior of the developing organ. Very satisfactory results have been obtained by treating fresh material with Schneider's acetocarmine, especially in the study of cellular contents of the germaria, young eggs, and eggs in earlier cleavage stages. This stain brings about an excellent differentiation of the nucleus and of the cytoplasm, but the tendency of the acetic acid contained in the solution to render somewhat opaque an originally semitransparent tissue makes it unsuitable for use in connection with older aphid embryos, where one has to deal with bulkier objects. Nor can it be used to advantage in connection with the study of the "symbiotic organs," as the stain destroys the original green pigment in the mass of "microörganisms." The entire egg constituents are thus reduced to the same color, and the "symbiotic organs" which are clearly discernible in the fresh material become obscured.

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[6] The arrangement in the present list follows the generic sequence in Baker's (1920) paper. Names marked with an asterisk indicate species for the identification of which I am indebted to Miss Edith M. Patch.

For making permanent preparations, I have used two groups of fixatives in which either picric acid or bichloride of mercury forms the principal active part. Of the former group, I have tried Kleinenberg's picro-sulphuric solution and Bouin's picroformol with acetic acid; and of the second, Gilson's mercuronitric mixture, Carnoy and Lebrun's fluid, and Webster and Phillips's (1912) sublimate-acetic-alcohol mixture. I have found that for general purposes the mixtures containing corrosive sublimate are more satisfactory, in that they have a stronger penetrating power and thus produce better preservation and less distortion in the tissues. Furthermore, material treated with these fixatives takes the stain much more sharply, especially when aniline dyes are used. Carnoy and Lebrun's fluid is too violent in its reactions and, for this reason, it has been employed in my work to a limited extent only, in connection with winter eggs, the thick chorion of which is not readily permeable to the milder solutions. Gilson's fluid, heated to about 80° C., has been used much more extensively than any of the other mixtures.

Viviparous aphids of different instars are brought into the laboratory and the abdominal walls are punctured once or twice with very fine needles, care being taken in performing the operation not to make the wounds too large as otherwise the body contents would ooze out. The specimens so treated are then dropped into the fixing fluid which has been previously heated to about 80° C. The aphids are almost instantly killed on contact with the liquid at this temperature and penetration by the fixative is also greatly enhanced.

Except where the embryos are to be mounted in toto, no advantage is gained by dissecting them out of the mother and embedding them separately. In fact, the advantages appear to be in favor of sectioning the entire aphid, for then considerable time is saved in at least three ways; namely, in being spared the trouble of dissecting; in that each embryo does not have to be embedded separately; and in the fact that in sectioning, from about thirty to a hundred eggs and embryos, depending upon the instar of the mother (see Table 1), are cut at one time from each block, where otherwise there would have been only one. While it is true that in sectioning the entire aphid, it is impossible to control the orientation of the abdominal contents, still I have found that in practically all my sections some of the eggs and embryos are cut on an exactly sagittal, frontal, or crosswise plane, while the rest present an oblique or tangential aspect. The latter are very useful in comparative studies of relationships and structure of the internal organs. A further advantage in preparing sections of whole aphids is that the normal bearing of the eggs, embryos, and the ovaries in their relation to the adjoining parts of the body is kept intact, as in its natural condition. Among the more serious disadvantages in connection with preparing individual embryos separately for sectioning is the fact that there is a noticeable amount of distortion of the different organs, due probably to the extreme delicacy of the embryonic tissue which makes it easily affected by too much handling and by direct exposure to the various reagents used.

Paraffines of two degrees of hardness have been used for embedding, one with melting point at 46° to 48° C., and the other, at 54° to 56° C. The use of clove oil as a clearing agent prior to the transfer of material to the paraffine bath was abandoned after several trials on account of its tendency to render the tissues too brittle. Xylene was found to be much more satisfactory. About one hour in the soft paraffine and three to four hours in the hard has been found sufficient for thorough impregnation of the objects. In preparing the blocks for sectioning, I have found that I can work much faster and obtain much more satisfactory results by using small watch glasses as molds, instead of paper boxes or other devices.

The objects are cut from 3 to 10 micra thick. Most of them are prepared at about 7 micra, this thickness having been found to be the most suitable for ordinary purposes. Frontal, sagittal, and a few cross sections have been made. Mayer's albumen has been used in fixing the paraffine ribbons onto the slides.

Borax carmine and alum cochineal both gave satisfactory results with embryos prepared in toto. For staining sectioned material, Ehrlich's acid hæmatoxylin, without counter stain, was largely employed and found to be highly suitable for general histological work. This solution gives a very good differentiation, with soft color contrast and, unlike Heidenhain's iron hæmatoxylin, does not obscure any of the tissues by staining them too black. Ehrlich's hæmatoxylin has the further advantage of acting relatively more quickly, and it yields a much larger percentage of good or otherwise usable slides than all the other stains I have used. Very beautiful preparations have also resulted from the use of safranin and gentian violet, according to the method described by Guyer.[7] For a more detailed study of cell structures, sections 3 to 5 micra thick are stained in Heidenhain's iron hæmatoxylin.

PARTHENOGENETIC EMBRYOLOGY AND HISTORY OF THE "MYCETOM"

GENERAL CONSIDERATIONS OF THE OVARIES

In as much as all the embryonic stages in parthenogenetic aphids are passed in utero, it seems advisable, for the sake of a more adequate understanding of some of the topics in the discussion which follows, to include in the present paper a description of the ovaries. The description herein presented is based on *Macrosiphum tanaceti* and on an allied species, *M. rosæ.*

The opening of the vagina is bounded externally by two large plates and a pair of smaller sclerites which, to use the terminology adopted by Tullgren (1909), are as follows: (*a*) Dorsally, a round-top, elongately subconical anal plate (Plate 1, fig. 1, *ap*), which is about one and one-fourth times as long as its dorsoventral basal diameter and the entire surface of which is sparsely set with elongate rows of abrupt spines and, here and there, a few long hairs, resembling in this respect the superficial characters of the style, or abdominal cauda; (*b*) ventrally, an acutely subconical genital plate (Plate 1, fig. 1, *gp*), which presents a coarsely punctate surface, sparsely set with moderately long hairs; and (*c*) laterally, on each side of the vaginal slit, a rudimentary gonapophysis (Plate 1, fig. 1, *gon*), which is considerably smaller than the anal plate and which possesses the same superficial characteristics as the genital plate.

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[7] Guyer, M. F., Animal Micrology, revised ed. Chicago, The University of Chicago Press (1917) 234.

From that opening, or slit, the vagina extends anteriorly to about the junction of the genital plate and the adjoining anterior abdominal sternite. The vagina, when empty, is compressed dorsoventrally, so that in cross section (Plate 2, fig. 18) the dorsal and the ventral vaginal walls are observed almost to touch each other. The greatest width of the vagina in this condition is about 126 micra. The wall consists of three layers: (*a*) A thin, innermost chitinous intima, which is continuous with the exoskeleton of the insect (Plate 2, figs. 16, 18, *int*). (*b*) A thick hypodermis (Plate 2, figs. 16, 18, *hyp*), which constitutes the main portion of the wall. This layer is about three or four times as thick around the rim of the vaginal slit as in the adjoining anterior portion. The hypodermal cells are elongately or abruptly columnar and, on account of the marked differences in the length of these cellular constituents, the ental surface of the hypodermis presents a rugged appearance. The nuclei are large in proportion to the size of the cell, subglobular or abruptly subellipsoidal, with a distinct nucleolus and numerous scattered chromatin granules. The cytoplasm is highly vacuolated. (*c*) A basement membrane, which serves as support for the muscles which operate the vagina. The muscular equipment of this organ appears to be most strongly concentrated around the vaginal slit. The muscles in this region are characteristically spindle-shaped, and measure about 40 to 45 micra long, being about twice the length of the muscles found in association with the more anterior portion of the vagina. They have their origin at the ental walls of the anal plate and of the rudimentary gonapophyses. The function of these muscles is apparently to open and close the vaginal slit. One important point to consider in connection with the vagina is the absence of the spermatheca and of the colleterial glands which, in amphigonous individuals, arise as an evagination of the vaginal wall. This peculiarity of the ovaries in parthenogenetic aphids was first reported by von Siebold (1839); I have already called attention to this fact in an earlier paper (Uichanco, 1921).

Two rather short oviducts are present. They measure approximately 70 micra in their greatest cross-sectional diameter. There is nothing of any particular interest in this region, except that the chitinous intima which lines the ental surface of the vaginal wall is absent here. The epithelial wall of the oviduct is considerably thinner than the hypodermis of the vagina. The former is composed of flat, subpolygonal cells, with large globular nuclei and highly vacuolated cytoplasm. The muscular equipment of the oviduct is very much sparser than that of the vaginal wall.

There are twelve ovarioles, or ovarian tubules, arranged in two equinumeral groups, each group joining posteriorly one of the two oviducts. A similar number has been observed by Balbiani (1869) and by Stevens (1905) in connection with other species of aphids. Each ovariole terminates anteriorly in a filament (Plate 3, figs. 21, 22, *fil*), which is connected with the dorsal diaphragm of the body of the mother at about the junction of the metathorax and the first abdominal segment. The terminal filament has an average diameter of 1.5 micra. It is noncellular and is apparently continuous with the investing membrane which envelops the ovariole. Entally a mass is visible containing numerous minute granular inclusions, the nature of which I was unable to determine satisfactorily on account of their extremely small size. These granules stain rather deeply in Ehrlich's acid hæmatoxylin, and in this respect are very suggestive of nuclear material. The function of the terminal filament is apparently to serve merely as mechanical support for the ovariole. This interpretation was first proposed by Stein (1847) in connection with similar structures in other insects. In aphids, this structure was apparently first noted by Huxley (1858).

The ovariole is a tubular structure which, owing to the presence of eggs in a longitudinal row from the subapical portion to the posterior end, presents a submoniliform aspect. The wall is composed of an ental epithelium, with the exception noted below, and an ectal investing membrane. The ovariole has two main divisions: the germarium, or terminal chamber (Plate 3, figs. 21, 22, 23, *gm*), and the vitellarium (Plate 3, figs. 21, 22, 23, *vit*). The former was first described by Leydig (1850) in viviparous aphids. It is subpyriform or subglobular, with the epithelium of the anterior and lateral walls reduced to a very thin membrane in which the cells show evidence of being widely stretched. The wall at the posterior end, on the other hand, is about five to ten times as thick as are the anterior and lateral walls. There seems to be reasonable ground to suppose that the thinner epithelium constitutes the lining of the terminal chamber, which is passive in its nature and takes no active part in the formation of the follicular epithelium of the egg; the thicker epithelial lining represents the mass of cells from which arises the latter tissue.

The vitellarium constitutes that portion of the ovariole into which the ovum is pushed upon extrusion from the germarium. The only static part of the wall of the vitellarium is the ectal investing membrane, in as much as the epithelial lining is represented by the follicular epithelium of the egg and the latter accompanies the egg or embryo in its downward migration into the oviduct. This state of affairs is partially in harmony with that obtaining in other insects in general, as characterized by Comstock (1920, pp. 158, 159) in the following words:

> * * * the epithelium lining of the ovarian tube becomes invaginated between the eggs in such a way that each egg is enclosed in an epithelial sac or egg-follicle, which passes down the tube with the egg. There is thus a tendency to strip the tube of its epithelium, but a new one is formed.

This view is confirmed by the aphid material I have examined, except for the fact that from Comstock's statement one would judge that the epithelial lining is stripped off along the entire length of the vitellarium. While this may be the case in certain other insects, it certainly is not in aphids, wherein the apportionment of epithelial lining to the egg takes place only at the anterior end of the tubule. The egg thus provided with a follicular epithelium passes posteriorly through the lumen of the vitellarium, the wall of which, to a greater extent, at this caudal portion consists only of an investing membrane and is devoid of an actual epithelial lining. The latter is represented by the egg follicle which from time to time, as one egg passes down after another, comes momentarily in contact with the investing membrane. Thus, strictly speaking, the epithelial lining of the vitellarium is stripped only from the anterior portion of the tubule, where it is continually replaced by proliferation of the epithelial cells at this region.

The embryonic life of the parthenogenetic aphid is spent in the vitellarium. Ovulation begins to occur early, even before the birth of the mother. The number of eggs and embryos in each vitellarium increases with the age of the mother, the number reaching its maximum limit some time after the latter has reached the adult stage. Since, when a young egg is extruded, the older ones are pushed posteriorly, the eggs and embryos in the vitellarium become arranged anteroposteriorly in a linear series in an ascendant chronological gradation.

SUMMARY

The ovary of a parthenogenetic *Macrosiphum* consists of a vagina, which is connected anteriorly with two short oviducts; and there are twelve ovarioles, or ovarian tubules, arranged in two equinumeral groups on each of the latter. Each ovariole is supported distally by a slender noncellular terminal filament, which is fastened anteriorly to the dorsal diaphragm of the insect, at about the junction of the metathorax and the first abdominal segment. The ovariole consists of a germarium, or terminal chamber, in which the oöcyte is lodged prior to extrusion; and a vitellarium, in which the embryonic life of the parthenogenetic aphid is passed. The eggs and embryos present in a vitellarium increase in number progressively with the age of the mother, and are arranged anteroposteriorly in a linear series in an ascendant chronological gradation.

DEVELOPMENTAL STAGES OF THE PARTHENOGENETIC EGGS AND EMBRYOS, IN THEIR RELATION TO THE AGE OF THE MOTHER

In an earlier publication (Uichanco, 1921) I cited the observations of Ewing (1916) on *Aphis avenæ* Fabricius and of Webster and Phillips (1912) on *Toxoptera graminum* Rondani, both of which papers reported cases of parturition occurring in what were thought to be nymphal forms of parthenogenetic females, as examples of pædogenesis in aphids. As has been satisfactorily explained by Turner and Baker (1915) and by Baker and Turner (1916a), both of which references I had overlooked in the preparation of my previous paper,[8] such aphid "nymphs" as have been observed to give birth to young are in reality adult "intermediates;" that is, individuals which have undergone the full number of molts and which possess all the characters of the alate adults, except that the wings are rudimentary. The rudimentary wings, as these authors have pointed out, have been mistaken for wing pads, and hence the erroneous interpretation. This citation in my earlier paper in connection with pædogenesis is, therefore, corrected here.

It has impressed me, however, that the methods heretofore employed in determining the nature of reproduction in aphids have been very superficial and unsatisfactory. The birth of young from viviparous females, which investigators have so far taken into consideration only in this connection, does not correspond to the phenomenon of egg deposition as this process is known in amphigonous individuals, but represents the conclusion of the embryonic life of the parthenogenetic aphid. The intrauterine development of the embryo, which corresponds to the incubation period of zygogenetic eggs, has not been taken into account. In neglecting this part of the aphid's ontogeny, we are using an imperfect criterion, and whatever conclusions we may draw therefrom are, of course, erroneous. With these premises in view, I have made an attempt in the present work to determine both qualitatively and quantitatively by dissection of individuals of definitely known ages the probable extent to which pædogenesis occurs in aphids. Observations had to be limited to one species, *Macrosiphum tanaceti,* living bred material having been used in all cases. Ringer's solution proved very satisfactory for examination media. Dissection was made under a pair of binoculars by means of tips of No. 0 steel insect pins which had been mounted on handles and ground to a fine point. An effort was made to keep the succession of eggs in the individual vitellaria intact, but on account of the extremely delicate nature of the ovarian walls, their accidental laceration was often unavoidable. The slightest rupture of the ovariole enables one or more of the eggs to escape, and since they thus disturb the sequence of the contents, that particular material is rendered useless for the purpose of experiments like the present ones. Owing to this difficulty in dissection, only one or two, and often none, of a total of twelve ovarioles present in each individual, can be studied.

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[8] I am indebted to Dr. A. C. Baker, of the Bureau of Entomology, United States Department of Agriculture, for kindly calling my attention to this oversight.

Observations were made in connection with mothers of the following instars. The letters correspond to those at the head of each column in Table 1.

A. Nymphs of the first instar, immediately after birth. The eggs present in the vitellaria at this age represent the total ovulation during the prenatal stages of the mother.

B. Nymphs of the second instar, immediately after the first molt. The eggs at this age represent the total ovulation during a period which begins with the prenatal stages of the mother and ends with the completion of the first instar.

C. Nymphs of the third instar, immediately after the second molt. The eggs at this age represent the total ovulation from the prenatal stages of the mother to the completion of the second instar.

D. Nymphs of the fourth instar, immediately after the third molt. The eggs at this age represent the total ovulation from the prenatal stages of the mother to the completion of the third instar.

E. Adults, immediately after the fourth molt. The eggs at this age represent the total ovulation from the prenatal stages of the mother to the completion of the fourth instar.

F. Adults, after they had given birth to the first young.

Total ovulation from the prenatal stages of the mother through the adult stage could be determined only approximately after the birth of the first young in the present experiments, for two reasons: (*a*) The individuals used were mostly bred en masse, which fact made it impracticable to determine which mother had given birth to the young; and (*b*) even in the case of individuals bred singly, the tendency of the walls of the ovarian tubules to rupture during manipulation made it almost impossible to determine, by comparison, from which one of the twelve vitellaria the young nymph had been extruded. In cases of mothers confined individually it will probably be possible to follow the rate of ovulation during the adult stage after the birth of the twelfth young and the multiples of this number. This number is taken since, as I have already noted, there are twelve ovarian tubules in the parthenogenetic *Macrosiphum tanaceti.* The corresponding eggs in each tubule in one individual are approximately of the same age and are presumably born in close succession to one another. Thus, for every twelve young born, there is to be made an allowance of one when the total contents of each ovarian tubule are counted.

Another method of determining ovulation in the adult stage is to count the total number of young born from the mother during the entire period of fecundity of the latter. The percentage of mortality of the embryos in utero, so far as I am able to determine by dissection, is nil or almost negligible. In as much as the latter two experiments were not started until rather late in the season, sufficient data have not been obtained for adequate discussion in the present paper.

The findings from dissections of individuals of known ages are presented in Table 1. This table shows clearly the number and the comparative degree of develoment of the eggs in each ovariole at the conclusion of the corresponding instar of the mother as well as the developmental history of each individual egg as observed at the conclusion of each maternal instar.

TABLE 1.—*Comparative stages and individual developmental history of eggs in one vitellarium at the conclusion of each instar in parthenogenetic Macrosiphum tanaceti.*

Egg No. (in postero-anterior sequence within vitellarium).	A. At birth.	B. First molt, about 48 hours after birth.	C. Second molt, about 30 hours after first molt.	D. Third molt, about 48 hours after second molt.	E. Fourth molt, adult, about 48 hours after third molt.	F. Adult, 3d day, about 80 hours after fourth molt.
I	Blastomeres differentiating, or blastoderm fully formed. "Germ cylinder" not evident, or beginning to proliferate.	Ventral plate extending to entire length of egg. No formation of metameric segments.	Beginning of metameric segmentation or formation of anlagen of appendages.	Embryo with differentiated appendages and nervous system. Immediately prior to, or in process of, or immediately after rotation of embryo.	Embryo with fully developed appendages, body wall and internal organs.	Full-grown young, being born.
II	Cleavage nuclei at periphery, preparatory to formation of definitive blastomeres.	Blastoderm. Ventral plate about one-third total length of egg.	Ventral plate extending to entire length of egg, hooked at anterior end. No metameric segmentation.	Anlagen of appendages. Prior to rotation of embryo.	Embryo soon after rotation. Some with body wall, appendages and internal organs well formed. About two-thirds length of I.	Well-developed young, about two-thirds length of I.
III	Egg freshly extruded, or with fully formed cytoplasmic mass.	Blastoderm newly formed. No "germ-cylinder."	Ventral plate about one-fourth total length of egg. "Germ-cylinder" beginning to proliferate.	Beginning of metameric segmentation.	Anlagen of appendages.	Embryo after rotation. Appendages differentiated; also body walls and internal organs. Hind legs extending only to abdominal cauda.

IV			Egg prior to cleavage, or first cleavage, or cleavage nuclei migrating to periphery.	Differentiation of blastomeres, or migration of cleavage nuclei to periphery.	Blastoderm. Ventral plate one-third to one-half total length of egg.	Ventral plate two-thirds to total length of egg. Some with beginning of metameric segmentation.	Embryo prior to rotation; anlagen of appendages.
V				Egg freshly extruded, or egg more or less well developed with large cytoplasmic mass.	Differentiation of blastomeres.	Blastoderm. Ventral plate beginning to proliferate, or one-half total length of egg.	Beginning of metameric segmentation.
VI					Egg freshly extruded.	Differentiation of blastomeres, or blastoderm and proliferation of "germ-cylinder."	Ventral plate about as long as egg.
VII						Egg being extruded, or first cleavage.	Ventral plate one-third to one-half total length of egg.
VIII							Differentiation of blastomeres. Egg very elongate and narrow.
IX							Egg freshly extruded, or fully formed, with large mass of cytoplasm.

DISCUSSION AND CORRELATION

The following deductions are made from an analytical study of Table 1:

1. Ovulation in parthenogenetic forms of *Macrosiphum tanaceti,* and apparently of many other species of aphids also, begins at a period when the mother is still in the embryonic state. This fact has been known for a long time. Metschnikow (1866) appears to be the first to report similar observations, in the following statement:

> Noch während des embryonalen Lebens der Aphisembryonen fängt die Entwicklung der neuen Generation an, wobei sie so weit geht, dass bei den, zum Gebären reifen Embryonen sich bereits zwei Keimfächer in jeder Eierstockröhre befinden, so dass das unterste ein Pseudovum mit ganz entwickeltem Blastoderm in sich einschliesst.

In general, my observations agree with his, except in the figure he gave for the number of eggs in the ovariole of the nymph at birth, as I am pointing out in the following paragraphs. He worked on "*Aphis pelargonii*" and "*Aphis rosæ,*" and it is quite probable that the discrepancy between his figure and mine is due to the difference in our experimental material. It is also probable that he had overlooked the very young oöcyte, which is just being extruded from the germarium at this age of the mother.

2. In all the newly born nymphs dissected, three eggs were found on the average in each vitellarium. From the very small size and relative scarcity of the surrounding cytoplasm, it is apparent that egg III[9] has been extruded from the germarium at about the conclusion of the prenatal stages of the mother or while she was being born. For this reason, only eggs I and II are really extruded during the embryonic stages of the mother. Thus in the twelve ovarioles present in each individual mother, a total of twenty-four eggs are extruded from the germaria before she is born.

3. The number of eggs extruded from each germarium during the various maternal instars and the time required in each case are given in Table 2.

4. As shown in Table 2, a much larger percentage of eggs is extruded during the preadult than during the adult stage of the mother. The total number of young born from each parthenogenetic female during her period of fecundity has never been

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[9] Roman numerals refer to egg numbers, as indicated in the first column in Table 1.

counted directly in the case of *Macrosiphum tanaceti.* Webster and Phillips (1912), however, who did very careful experimental work, based on a large number of individuals, on a closely allied species, *Toxoptera graminum* Rondani, published the following statements on the fecundity of viviparous forms:

> The maximum number of young produced by those born from March to the middle of June is 69, the average number for each individual for this period being 30.3; the maximum for those born from the middle of June until the middle of August is 93 young, the average number for each individual being 25.3; the maximum for those born after the middle of August is 66 young, the average for each individual being 24.

TABLE 2.—*Comparative rate of ovulation in different maternal instars, computed from Table 1.*

Stage of mother.	Eggs extruded from germarium.	Approximate time requirement.
		Hrs.
Prenatal	2	[a] 55
First instar	2	48
Second instar	1	30
Third instar	1	48
Fourth instar	1	48
Adult	[b] 2	80

[a] Calculated average from Table 3; 2 days 7 hours = 55 hours.

[b] Adults dissected after birth of first young. This number does not take into account possible subsequent ovulation.

The maximum obtained by these authors for all their experiments is 93 young. So far as I have carried the experiments on *Macrosiphum tanaceti,* which has reached the adult stage and begun to give birth to her young, the number of eggs present in the vitellarium at any one time is 9, which makes a total of 108 in the twelve ovarian tubules. If all of these are born as young, this maximum figure obtained from dissection of *Macrosiphum* is rather close to the maximum number of young observed by Webster and Phillips on *Toxoptera graminum.* After expulsion of the first young from the vitellarium, therefore, it is doubtful if ovulation proceeds to any appreciable extent beyond the maximum figure I have obtained. Taking 9, then, as an approximately close estimate for the maximum number of eggs which pass into each vitellarium of a parthenogenetic *Macrosiphum tanaceti,* we see from Tables 1 and 2 that ovulation occurs mainly in the embryonic and nymphal stages of the mother, only about 25 per cent of the total being extruded during the adult stage.

5. Cleavage and subsequent development proceed soon after the eggs are extruded from the germarium.

6. By following egg No. I in Table 1 to the conclusion of each maternal instar, it will be noted that:

a. The latest stage reached by the oldest egg in the vitellarium at birth of the mother is the blastoderm stage in which the germ cylinder is not yet in evidence or is just beginning to proliferate (Plate 1, fig. 38 or 39; or Plate 6, fig. 40).

b. The formation of metameric segments and the appearance of the anlagen of the appendages (Plate 7, fig. 44; or Plate 8, fig. 49) do not occur until about the conclusion of the second instar.

c. At about the conclusion of the third instar, the oldest embryo has the nervous system, mouth parts, legs, and other parts of the body well differentiated (Plate 9, fig. 51; or Plate 10, fig. 53; or Plate 11, fig. 56; Plate 12, fig. 57). The invaginating stomodæum and proctodæum are fully in evidence. Rotation, or orientation, of the embryo does not occur until about this time. By inference, it also follows that rotation of the embryo does not occur until after the parts indicated above are differentiated.

d. At the conclusion of the fourth instar, that is, as the mother is passing into the adult stage, the oldest embryo in her ovariole has fully developed appendages, body wall, and internal organs (Plate 1, figs. 6, 7, 8), but is noticeably smaller than the corresponding ones which are about ready to be born in older mothers (Plate 1, fig. 10).

7. In as much as the extrusion and subsequent development of about 75 per cent of the parthenogenetic eggs occur during the preadult stages of *Macrosiphum tanaceti,* only about 25 per cent of the total ovulation taking place in the adults, pædogenesis may be considered as a normal method of reproduction in this and probably in other species of aphids. This point was not brought out in my previous paper (Uichanco, 1921). The occasional observations on parturition during the apparently nymphal stage of aphids is really not an adequate basis for judging the extent of pædogenetic development which is going on within the ovaries of the viviparous mother. The extrusion of the eggs into the vitellaria and the subsequent intrauterine development of the former while the mother is still in the embryonic or nymphal stage may be considered as satisfying the conditions for pædogenetic reproduction, irrespective of whether the young is born during the preadult stages of the

mother or later. The classical case of *Miastor metraloas,* discovered by Wagner (1862), and to which von Baer (1863) applied the name "pædogenesis," occurs in the form of a larva which gives birth to another larva. The general principle involved in the two types, represented by parthenogenetic aphids on one hand and by *Miastor* on the other, is the same, the difference in the visible manifestation of the end products being, so far as biological significance of pædogenesis is concerned, of minor importance. Or, as Wilder (1909, pp. 21 and 22), speaking in general terms of reproduction in animals, so aptly expressed it—

> the developmental history of an animal includes all stages from that of a fertilized egg (ovum) to that of the sexually matured adult, and is not in any way interrupted by the act of birth or hatching. These latter are purely external phenomena, and mark no important stage in the development of an animal, save in the line of certain necessary adaptations.

In order to avoid confusion of terminology, however, there appears to be a necessity for a new definition of the original term, and the following reclassification is hereby proposed:

I. PÆDOGENESIS (*pædo-*, or *pedo-*, from παἳς, παιδός, child, + genesis, from γένεσις, from root of γἵγνεσθαι, to be born). Definition: That method of sexual reproduction whereby during the immature stages of the mother the ovum reaches a condition which enables it to begin a new germ-cell cycle.[10]

  1. BISEXUAL PÆDOGENESIS.[11] Definition: That form of pædogenesis wherein the union of biparental elements accompanies reproduction. The preadult individuals in such cases "attain sexual maturity and produce eggs and sperms." Examples: *Bolina hydatina* (Ctenophora) and *Ambystoma tigrinum* (Chordata) (Shull, 1920, pp. 181–183).
  2. UNISEXUAL (PARTHENOGENETIC) PÆDOGÈNESIS.[12] Definition: That form of pædogenesis wherein the development of the ovum takes place without fertilization. As I have pointed out in the foregoing discussion, in the viviparous forms, the extrusion of the ovum from the germarium and the subsequent intrauterine development thereof correspond in their biological significance to oviposition and the subsequent incubation of the eggs in the ovipara.

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[10] The term "germ-cell cycle" is adopted here in the sense discussed by Hegner (1914, pp. 28–29).

[11] The idea of divisions 1 and 2 in the present classification is drawn from Shull (1920, pp. 181–183).

[12] The definition in my previous paper (Uichanco, 1921) to the effect that "pædogenesis is parthenogenesis occurring in the preadult stages of animals" is no longer tenable, because too involving, and should be corrected to conform with the present classification.

a. UNISEXUAL ECTOPÆDOGENESIS (*ecto-*, from ἐκτός, outside, + pædogenesis).[13] Definition: That form of unisexual pædogenesis wherein the externally visible manifestation of the end products, in the form of extraovarian extrusion of eggs or young, occurs during the preadult stages of the mother. Examples: Certain groups of Itonididæ, like *Cecidomyia* (in some of the species only) and *Miastor*.

b. UNISEXUAL ENTOPÆDOGENESIS (*ento-*, from ἐντός, within, + pædogenesis). Definition: That form of unisexual pædogenesis wherein the development of the ovum takes place in utero during the immature stages of the mother, and consequently the externally visible manifestation of the end products, in the form of extraovarian extrusion of eggs or young, does not occur until subsequently. Examples: Parthenogenetic Aphididæ.

At this juncture, Pérez's (1899) definition of metamorphosis (in the sense of successive abrupt changes undergone by an organism during the course of its development) as "une crise de maturité génitale" may be aptly considered. Giard (1900) has published a refutation of Pérez's views and raised the following questions:

> Toute métamorphose est-elle accompagnée d'une crise de maturité génitale?
>
> Toute crise de maturité génitale est-elle forcement accompagnée d'une métamorphose?

He makes an attempt to show that the foregoing two questions demand in general a negative answer, basing his arguments on the behavior of certain groups of animals, principally insects. His contention is that metamorphosis is not dependent on the development or nondevelopment of the genital organs, for in cases of parasitic or alimentary castration, the development of the rest of the body appears to proceed normally. He also makes an effort to show that the reverse is likewise true; that is, the development of the genital organs is independent of metamorphosis, using as his examples the fact that in neoteinic individuals of certain animals sexual maturity is reached before metamorphosis is completed and, further, in cases where alimentary castration is suppressed, as in the queen of Vespidæ, acceleration of development of genital organs takes place without a corresponding effect on metamorphosis. He also cites the case of parthenogenetically reproducing insects, which, he claims, have dispensed with their adult stage. He is, however, wrong in the case of the aphids. The viviparous generation of this family has not, as he says, suppressed the imaginal stage, for parthenogenetic individuals with fully developed wings are produced.

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[13] Von Baehr's (1863) "pædogenesis" and Hatschek's (1877) "pædoparthenogenesis," the latter term being used also by Henneguy (1904, pp. 259, 260), come under this heading. "Pædogenesis," as I have already noted, includes several other categories which have come to light since the original term was coined and, therefore, needs a revision in definition. "Pædoparthenogenesis" is unsuitable because ambiguous. The term would include both (*a*) and (*b*) in the present subdivision.

Neither Giard nor Pérez has defined the meaning of *"une crise de maturité génitale."* From their discussion, however, it is apparent that what is meant is the condition whereby the reproductive organs begin to become functional; that is, when mature ova or spermatozoa begin to be produced. In this sense, sexual maturity in parthenogenetic aphids takes place soon after differentiation of the definitive ovarian tubules, when the insect is still in the prenatal stages. My own observations on parthenogenetic aphids appear to confirm the views of Giard in that "sexual maturity" is independent of somatic development. The general occurrence of birth of young in the adult stage of parthenogenetic aphids is apparently a mere case of normal coincidence, as the time required by the older parthenogenetic eggs to complete their intrauterine incubation and the time required by the mother to reach the adult stage from the date in which ovulation begins to take place are generally of almost equal duration. Presence of disturbing factors which may bring about a retardation in the metamorphosis of the mother, accompanied by a normal or more rapid development of the egg, or an unusually rapid development of the egg in a normally growing mother, will probably bring about parturition during the preadult stages of aphids.

8. As shown in Table 2, the time intervening between the extrusion of an egg in the ovarian tubule and that of the next one is from about twenty-four to about forty-eight hours. The rate of ovulation is apparently slightly more rapid during the prenatal stages and the first two nymphal instars than during the succeeding ones.

SUMMARY

1. Two eggs are extruded into each vitellarium during the embryonic stages of the mother. At birth, the mother has three eggs present in each vitellarium, the one located most anteriorly being just in the process of extrusion, and the rest, in a more or less advanced state of development. The oldest is in the early blastoderm stage.

2. A much greater percentage (about 75) of the total number of eggs which a female produces during her period of fecundity is extruded during the preadult than during the adult stage of the mother.

3. Cleavage and subsequent development of the egg proceeds soon after extrusion from the germarium.

4. Metameric segmentation of the oldest embryo within the ovary of a parthenogenetic female takes place at about the conclusion of the second instar of the mother.

5. Rotation, or orientation, of the oldest embryos occurs at about the conclusion of the third instar of the mother. At about this time, they have the nervous system, mouth parts, legs, and other parts of the body well differentiated.

6. By the time the mother reaches the adult stage, the oldest embryos have the different parts of the body completely formed and possess the general form which they finally assume when they are ready to be born, except for the relative proportion of the appendages and of the other parts of the body to one another, and for the fact that these embryos are smaller.

7. The extrusion of parthenogenetic eggs into the vitellarium of an immature mother and the subsequent intrauterine development of the former represent a true case of pædogenesis. The term unisexual entopædogenesis, as a subdivision of pædogenesis, is proposed for this peculiar method of reproduction in parthenogenetic aphids.

8. "Sexual maturity" in parthenogenetic aphids is apparently independent of somatic development. Presence of disturbing factors which upsets the balance of normal coincidence in the two processes will probably bring about parturition during the preadult stages of the mother.

OVULATION DURING THE EMBRYONIC STAGES OF THE MOTHER IN THE PARTHENOGENETIC GENERATION

An attempt was made in the present experiments to determine the length of time ovulation goes on in the embryonic mother previous to birth of the latter. It may be necessary in this connection, for the sake of clarity, to restate briefly a few of the pertinent points which I have discussed before. During the embryonic stage of the mother two eggs are extruded into each vitellarium. They proceed in their development and the older one grows to the early blastoderm stage by the time the mother is born. At about this time also, a third egg just begins to appear from the germarium. In the twelve ovarian tubules, which is the number present in one individual, twenty-four eggs are, therefore, extruded during the prenatal stages of the mother. The embryos that are in homologous location in the ovarian tubules of an individual are of practically the same age and are apparently born in close succession to one another. From dissection of *Macrosiphum* in different instars, as shown in Table 1, the discrepancy in age between any two successive eggs in the same vitellarium is so great that the embryo situated nearer the germarium is not likely to be born before all the other embryos in the rest of the ovarian tubules which are homologus in location to the one that had preceded it are expelled. Other things being equal, the succession at birth between the first and the thirteenth young, the thirteenth and the twenty-fifth, etc., probably corresponds to the interval of time between the extrusion of the first and the extrusion of the second egg in each individual ovarian tubule; of the second and the third; and so on, respectively. Taking the third egg in the ovariole as marking the conclusion of ovulation in the embryonic stages, since it is just being extruded from the germarium at the time of birth of the mother, the intervening period to this point from the extrusion of the first egg in the same ovariole represents the period of prenatal ovulation. The only way in the present experiments by which the time intervals in the succession of any particular eggs in the same ovarian tubule may be determined is by resorting to the indirect method of observing the sequence of birth of the young which have presumably developed from those eggs. The time intervening between the extrusion of the first and that of the third egg in the same ovariole apparently corresponds to the time intervening between the birth of the first and that of the twenty-fifth young. Table 3 gives the breeding results on ten parthenogenetic adults of *Macrosiphum tanaceti* on which records have been kept of birth rate. In this table, I have given the time elapsing between the birth of the first and that of the twenty-fifth young as that of prenatal ovulation.

The figures given in Table 3 appear to have the following significance: Birth of the first young ordinarily takes place in *Macrosiphum tanaceti* from a short time after the last molt to about the third day of the adult stage of the mother. Now, the first young at about one day and fourteen hours (minimum given in Table 3) to about three days and one hour (maximum) before birth is contained within an aphid which is either in the later part of the fourth instar or the earlier part of the adult stage (see Table 1). As is also shown in Table 1, the first young in the ovarian tubules of the mother at this stage has the body wall fully formed, and the appendages and internal organs well differentiated. It is in many respects a perfectly developed nymph, except that it has not yet attained the full size which it is to have when ready to be born. It seems justifiable to make the deduction from the foregoing facts that ovulation does not begin in the embryo until after it has undergone rotation and the definitive body walls have been formed. This condition is more or less to be expected, in view of the fact that the differentiation of the definitive internal organs, including the ovarian tubules, is not completed until after the embryo has reached this stage. Another deduction which may be made here is that ovulation does not ordinarily begin to take place in any of the parthenogenetic embryos until after the mother containing the latter has reached the later part of the fourth instar or the earlier part of the adult stage.

TABLE 3.—*Period of ovulation in parthenogenetic embryo of Macrosiphum tanaceti Linnæus prior to birth.*[a]

Culture No.	Date of birth of 1st young.			Date of birth of 25th young.			Period of prenatal ovulation.	
	1921.	*a.m.*	*p.m.*	1921.	*a.m.*	*p.m.*	*Days.*	*hrs.*
1	June 7	9		June 9	8		1	23
2	June 7	9		June 9		7	2	10
3	June 7	9		June 9		7	2	10
5	June 7	12		June 9		6	2	6
6	June 7	8		June 10	9		3	1
7	June 7	8		June 9		2	2	6
9	June 6	9		June 9	8		2	23
10	June 7		2	June 9		7	2	5
11	June 7		7	June 9		2	1	19
16	June 7	5		June 8		7	1	14

[a] Maximum, 3 days 1 hour; minimum, 1 day 14 hours; average, 2 days 7 hours.

SUMMARY

By correlating breeding observations with results obtained from dissection, it has been found that the period at which ovulation, that is, extrusion of egg from the germarium, begins to take place in the embryonic mother ranges from about one day and fourteen hours to about three days and one hour, the average being about two days and seven hours before the birth

of the latter. Deduction is made from the foregoing figures that ovulation does not begin to take place in the embryonic mother until after the latter has the body wall completely formed and the internal organs fully differentiated. Further, the commencement of ovulation in the embryonic mother apparently occurs coincidentally with the time that the mother bearing this embryonic mother reaches the later part of the fourth instar or the earlier part of the adult stage.

INCUBATION PERIOD OF THE PARTHENOGENETIC EGG

Like the preceding observations on the prenatal ovulation in *Macrosiphum tanaceti*, the incubation period of a parthenogenetic egg, that is, the time required from the extrusion of an individual egg from the germarium to the birth of the nymph which develops from that egg, can be approximately determined indirectly by correlating the results of breeding experiments with those on dissection of individuals of known ages. I have pointed out in the foregoing discussion that at the time the mother is born each one of the twelve ovarioles contains three eggs—two that had been laid within about one day and fourteen hours to about three days and one hour prior to birth of the mother, and a third that is beginning to be extruded at about the conclusion of the last prenatal stage. The incubation period of a parthenogenetic aphid egg, on the basis of this third egg, is calculated by recording the length of time that elapses from the birth of the mother, through her nymphal and adult stages, to the birth of her twenty-fifth young. The birth of the twenty-fifth young marks approximately the conclusion of the incubation period of the third egg in the ovariole that had presumably been the source also of the first-born young, there being normally two embryos which will have to be expelled from each of the twelve ovarioles before the third one in the first ovariole is deposited. One difficulty with the present method of calculation is that it is obviously impossible to prove that the first and the twenty-fifth nymph developed respectively from the first and the third egg in the same ovariole. Granting, however, that they each come from a different ovarian tubule, and that the correct nymph is born later than the twenty-fifth, the discrepancy in age among the third eggs in the twelve ovarioles is apparently too slight to become a serious source of error. Table 4 gives the calculated data on the incubation period of ten parthenogenetic eggs.

TABLE 4.—*Incubation period in parthenogenetic generation of Macrosiphum tanaceti Linnæus.*[a]

Culture No.	Date of birth of mother.			Date of production of 25th young.			Duration of incubation period.	
	1921.	*a.m.*	*p.m.*	1921.	*a.m.*	*p.m.*	*Days.*	*hrs.*
1	May 27		6	June 9	8		12	14
2	May 27		6	June 9		7	13	1
3	May 27		6	June 9		7	13	1
5	May 27		6	June 9		6	13	0
6	May 28	9		June 10	9		13	0
7	May 28	9		June 9		2	12	5
9	May 28	8		June 9	8		12	0
10	May 28	10		June 9		7	12	9
11	May 28	10		June 9		2	12	4
12	May 28	10		June 9	10		12	0

[a] Maximum, 13 days 1 hour; minimum, 12 days; average, 12 days 13 hours.

Viviparous reproduction in aphids has been referred to as a "short-cut" method of multiplication. The findings in the present experiments tend to furnish concrete evidence in support of this statement. In the amphigonous generation the entire time spent by the eggs within the ovary of the mother is used up in the accumulation and storage of food material and in the formation of the protective layers of vitelline membrane and chorion for the future embryo. The eggs are, moreover, dependent on being previously fertilized by the male spermatozoa before development can proceed. Cleavage and subsequent formation of the embryo does not begin until after the eggs are laid.

In the case of parthenogenetic aphids, on the other hand, development goes on after the egg is extruded from the germarium, even during the prenatal stage of the mother, and the complete embryonic formation takes place within the maternal ovary. The male element is not depended upon for the initiation of development. Time is further saved by using the nutriment from the body of the mother directly as it enters the egg, and the delay which would otherwise have been occasioned by the intermediate process of storage of food material, as in amphigonous eggs, is thus eliminated. On account of absence of biological data on amphigonous forms of *Macrosiphum tanaceti,* I am unable to make an estimate of the actual time saved by parthenogenetic reproduction in this species. Such comparison, however, is possible for another species, *Aphis pomi* de Geer, for which Baker and Turner (1916) furnish very complete life-history data. These authors report that the nymphal life of the parthenogenetic form of this species embraces a period of ten to eleven days, as against sixteen to thirty-six days for a similar stage in the amphigonous female individuals. The first young in parthenogenetic mothers is born about twenty-four hours after the fourth molt of the latter, while the first egg in the amphigonous is not laid until after about two to four days have elapsed. The first egg in the amphigonous *Aphis pomi,* like the first parthenogenetic egg, is probably extruded into the vitellarium some time during the embryonic stage of the mother. I have found this to be the case in certain other species I have dissected, like *Macrosiphum tanaceti, Aphis euonomi* Fabr., and an unidentified species on *Shepherdia* (*Elæagnus*) *argentea.* Even if we suppose, however, that the period of prenatal ovulation is shorter in the amphigonous form, still the difference in time from the extrusion of the egg from the germarium to the formation of the full-grown embryo would be in favor of parthenogenetic reproduction. In the case of the first egg of the amphigonous individual, the entire time during the nymphal stage of the mother, which is sixteen to thirty-six days, is spent in accumulating the necessary substances for the proper maintenance and protection of the future embryo; the initial steps in embryonic formation do not begin until after oviposition. On the other hand, as soon as the first parthenogenetic ovum is extruded from the germarium, while the mother is still in her embryonic stage, it undergoes cleavage, forms the blastoderm, and during the ten to eleven days of the nymphal life of the mother, passes through the embryonic development; so that, in about twenty-four hours after the mother reaches maturity, the young is ready to be born as a perfect nymph, and not as an egg that has just been fertilized and is only preparing to cleave, as in amphigonous reproduction. As has been noted by Leydig (1850), Lubbock (1857), Huxley (1858), Leuckart (1858), Balbiani (1871), and other authors, there is no fundamental difference between the development of the amphigonous and that of the parthenogenetic egg, except in time of initiation of development and, of course, in the nonparticipation of the male elements in the latter process. Leuckart (1858, p. 346) gives a concise summary of the subject in the following words:

> Beiderlei Gebilde sind allerdings als Zellen zu betrachten, die sich auf analoge Weise in einen Embryo entwickeln, aber in dem einen Falle, bei den Keimzellen, beginnt diese Entwicklung bereits ausserordentlich frühe, schon zu einer Zeit, in der das Material für den Aufbau des Embryo noch

> lange nicht vorhanden ist, während im anderen Falle, bei den Eiern, die Entwicklung des Embryo in einer sehr viel späteren Zeit anhebt, erst dann, nachdem dieses Material vollständig herbeigeschafft und durch Ausscheidung einer festen Hülle nach aussen abgeschlossen ist.

The advantages accruing to certain groups of animals as a result of parthenogenesis, which have been pointed out by Weismann (1904, 2, p. 243) in connection with daphnids, appears to be shared by the aphids, as may be inferred from the foregoing discussion. Weismann says in part:

> Parthenogenesis effects a very considerable increase in the fertility of a species, and in this increase the reason for its introduction among natural phenomena obviously lies. By the occurrence of parthenogenesis, the number of ova produced by a particular colony of animals may be doubled, because each individual is a female, and as the multiplication increases in geometrical ratio a few parthenogenetic generations result in a number of descendants enormously in excess of those produced by bisexual reproduction.

SUMMARY

The incubation period of the third oldest egg in the ovariole, which is the egg that has been found to be in the process of extrusion from the germarium at birth of the mother, is followed indirectly by recording the time elapsing between the birth of the mother and the birth of the twenty-fifth young from this mother. The incubation period has been calculated as ranging from twelve days to thirteen days and one hour, the average being twelve days and thirteen hours.

The entire embryonic development of the parthenogenetic aphid takes place in the ovariole. A great economy in time is effected by the viviparous, parthenogenetic method of reproduction, as compared with the amphigonous, to say nothing of a greater assurance of the production of offspring in the former, on account of its independence from the male fertilizing element. Further, each individual being a female in parthenogenetic reproduction, the number of ova produced "may be doubled" and thus insure a considerable increase in the "number of descendants enormously in excess of those produced by bisexual reproduction."

THE GERMARIUM, OR TERMINAL CHAMBER OF THE OVARIOLE, AND ITS INCLUSIONS; THE FORMATION OF THE EGG FOLLICLE

The germarium of parthenogenetic *Macrosiphum* presents a subellipsoidal or subpyriform aspect, with the distal half or two-thirds usually somewhat larger in cross-sectional diameter than the proximal. In the later nymphal instars and in the adults, it tends to assume an elongately subglobular form. At about the time of or a little after differentiation in the embryonic mother (Plate 3, fig. 20), prior to the extrusion of any of the oöcytes into the vitellarium, the germarium is obovoid, and measures from 32 to 36 micra long and 18 to 23 micra in its greatest cross-sectional diameter. The enveloping wall at the anterior and lateral portions is lined entally with a single layer of cells which is almost uniformly 1 micron in thickness throughout. The component cells average about 2 micra in length, and show no signs of very marked stretching. This layer of cells represents the epithelium of the germarium.

A small posterior portion of the germarium is bounded by a much thicker wall (Plate 3, fig. 20, *a*), which is multilaminar at this region, and of which the component cells are about one and one-half times or twice the size of those of the anterior wall. This layer of cells protrudes posteriorly into the vitellarium. This tissue gives rise to the follicular epithelium of the egg and, for this reason, I shall hereafter refer to it as the formative egg follicle. The vitellarium at this stage is about 3 to 4 micra in cross-sectional diameter.

Plate 3, fig. 22, *a*, shows a stage in the later history of the formative egg follicle. The component cells have grown considerably larger, now averaging about 3 micra in their largest expanse, and the nuclei, which are subellipsoidal, about 2.5 micra in length. I have not been able directly to observe mitosis in this region but, judging from their very considerable increase in number, the cells must have proliferated actively, and it is probably the rapidity with which cell division takes place that makes it difficult to find karyokinetic figures among them. The illustration just referred to also shows an egg in the process of extrusion from the germarium, and the formative egg follicle completely inclosing the former. There can be little doubt that the following process occurs: This thick epithelium is the matrix of the egg follicle. It divides rapidly and in this way covers the developing egg, from the posterior pole anteriorly. Finally, as growth of the formative egg follicle proceeds, its layer of cells soon closes over the anterior pole of the egg (Plate 3, fig. 23, *a*), thus completely inclosing the latter. In this manner, the egg is provided with a follicle. That part of the epithelium now bordering the anterior pole of the egg thickens considerably and replaces the original matrix. In the meantime, another egg is extruded from the vitellarium. The process of formation of the follicular epithelium of the egg by posteroanterior circumcrescence is then repeated, each succeeding matrix of course being a direct descendant of the original formative egg follicle. As each new egg makes its appearance in the vitellarium, the older eggs are pushed, perhaps mainly by mechanical propulsion resulting from increase in pressure from the anterior region, toward the posterior portion of the tube. The follicular epithelium which incloses the egg, together with the corresponding matrix of the former, accompanies it in its downward migration.

The remnants of the matrices (Plate 3, fig. 22, *c*) persist for a time as solid, subcylindrical structures, with their component cells identical with those of the egg follicle proper. Each of these structures forms a posterior peduncle connecting one egg chamber with the contiguous one. The peduncle probably performs the same physiological functions as the egg follicle proper, which are mainly nutritive, in addition to serving as a cushion between neighboring egg chambers, and—a very important purpose—as storage tissue for the "symbionts" which, as I shall describe later, infect the egg through the posterior pole. This structure apparently degenerates later, or becomes absorbed as an integral part of the egg follicle proper during the stretching of the latter, thus ultimately setting the egg chambers free from each other.

Observations somewhat similar to the earlier phases of egg-follicle formation have been reported, in a rather cursory way, by Metschnikow (1866), and somewhat crudely represented in Plate 28, figs. 1 and 7, of his paper. He notes that—

> die am untersten Pole des Endfaches liegende Zelle sich bedeutend vergrössert, wobei sie in ein, aus dem Endfachepithel entstandenes Follikel eingeschlossen wird und hier ihre weitere Entwicklung vollzieht.

He has not followed the details of the process any further.

Figure 22 also shows a marked stretching of the epithelial lining of the anterior and lateral walls of the germarium, as a result of the increase in volume of the cellular elements inclosed in the chamber. In fig. 20, the corresponding epithelial cells in this region average about 1 micron thick and 2 micra long; but in fig. 22 they are shown to have stretched to about 7 micra in length, this increase probably being due also, partially, to growth, while their thickness has been reduced to 0.4 of a micron. The nuclei average about 6 micra in length and about 0.2 of a micron in thickness.

The cavity of the germarium is occupied by a mass of cells which are apparently potentially subglobular but which, owing to mutual pressure, present a subpolygonal aspect. In the terminal chamber, in a young embryonic mother, such for instance as the one shown in Plate 3, fig. 20, which represents a very young ovariole of *Macrosiphum rosæ* drawn from an embryo which is three-fourths the size of a full-grown one, the cellular inclusions average about 5 micra in diameter. They are almost uniformly similar in size, shape, and structure. The surrounding cytoplasm is finely granular, with no evidence of vacuolation. The nuclei are subglobular, with a well-defined nuclear membrane and with chromatin granules sparsely distributed in the karyolymph. The nucleoli are not very distinct. I have never observed any of these cellular inclusions in mitosis, although de Baehr (1920) claims that at this stage, in "*Aphis palmæ*," "généralement un grand nombre des oogonies se divisent a méme temps (synchroniquement)."

With the subsequent growth of the ovariole, however, a stage is reached in which these cells exhibit marked differences. Plate 3, fig. 21, drawn from a full-grown embryo of *Macrosiphum rosæ* which is almost ready to be born, shows this change. All the cells are approximately equal in size, all being about 7 or 8 micra in diameter. Within the anterior two-thirds of the germarium, the cells (fig. 21, *og*) have a subglobular nucleus with a clearly defined nuclear membrane and a distinct nucleolus. Numerous chromatin granules are scattered evenly in the karyolymph. In proportion to the volume of the nucleus, there is present a large amount of cytoplasm, which stains somewhat deeply in Ehrlich's acid hæmatoxylin and which is very highly vacuolated. The cells located posteriorly (fig. 21, *oc*), which are less numerous than those at the anterior portion of the germarium, on the other hand, differ from the anteriorly situated ones in that their nuclear membranes are not very distinct. By contrast also, their cytoplasm shows very little sign of vacuolation. The latter is finely granular, stains deeply with Ehrlich's acid hæmatoxylin, and forms a relatively much thinner sheet surrounding the nucleus. There is no distinct nucleolus, and the chromatin material has gathered together centrally into a loose subglobular mass of discrete, darkly staining, irregularly shaped, elongate bodies. A clear sheet of karyolymph surrounds this mass, occupying a considerable space between the periphery of the latter and the ectal boundary of the nucleus.

This difference in cytological structure between the two groups of cells is interesting in that it has been responsible in part for a protracted discussion among workers on aphid embryology in regard to the true nature of the cellular inclusions in the germarium of parthenogenetic aphids. There are two conflicting views, which may be briefly summarized as follows:

1. The cellular inclusions of the germarium represent only true oöcytes, there being no nurse cells present in parthenogenetic aphids. Among more recent workers, this view has been supported mainly by Stevens (1905) and by Mordwilko (1907).

2. The cellular inclusions represent two kinds of cells: nurse cells and true oöcytes. Will (1883) was an early advocate of this view. He claims that the nurse cells are pedunculated and are arranged radially around a central "rachis." The latter is connected posteriorly with a nutritive string which, according to him, serves to conduct the formative yolk substance from the nurse cells to the developing egg, as in amphigonous aphids. This author regards the pedunculated cells in the terminal chamber as egg anlagen which have lost their power of becoming eggs. One of Will's predecessors, Claus (1864), has proposed somewhat similar views, although he did not recognize any nurse cells, but did recognize glandular cells, by which he probably also meant the former. Among the more recent supporters of Will's view are Tannreuther (1907) and de Baehr (1920).

De Baehr gives a convenient summary of this phase of the subject in his paper. His criticisms against the evidence presented by the sponsors of the first view and his contention in favor of the stand he takes appear on superficial examination to be plausible, except for the fact that his arguments are weakened by the very poor figures which he used in his illustration. In justice to this author, however, it must be mentioned here that, as he states in his paper, he had lost his more carefully prepared drawings during the recent European War and that he was thereby compelled to resort to a hastily prepared and less satisfactory substitute. In his Plate 1, figs. 1, 2, and 3, in which he represents what he thought were the oöcytes and the nurse cells within the germarium, the morphological distinction and the location of these two groups of cells are not sufficiently convincing. The cellular elements which he took for oöcytes appear to me to be the cells of the formative egg follicle at the posterior portion of the terminal chamber which, in sectioned preparations, are often in the way, and may at times be so situated as to be mistaken for cellular inclusions of the germarium.

In my own work, in which I have examined numerous slides of two species, *Macrosiphum tanaceti* and *M. rosæ*, the structural differences of the cellular inclusions which I have described above are well marked in the latter only. In *M. tanaceti,* some of the cells found at the posterior portion of the full-grown germarium show large masses of chromatin granules which are scattered in the karyolymph (Plate 3, fig. 22, *oc*). The nucleolus is absent. In these particulars, they are very suggestive of the nuclear structure of the young ovarian egg (*ov*), which is represented in the same figure as being extruded from the germarium. In other respects, however, these posteriorly located cells are very similar to those at the anterior portion of the terminal chamber (fig. 22, *og;* fig. 24), the only visible difference being that the latter are in a resting state and possess distinct nucleoli.

Adult *M. tanaceti* were dissected four days after their emergence, in order to determine the contents of the germarium at this stage. Practically all the eggs that a parthenogenetic female of this species is capable of producing will have been extruded from the germarium by this time. This conclusion appears to be supported by the fact that, in all of the females at this age that I have dissected, the germarium is adjoined posteriorly by an egg in a very advanced state of growth, often being in a later stage of blastoderm formation, while occasionally it is found to have developed as far as the beginning of the metameric segmentation of the germ band. No ovarian egg was seen in the process of extrusion, indicating that at about this period in the life of *Macrosiphum* ovulation ceases. The germarium at this time still incloses from fifteen to twenty cellular elements, with a subglobular nucleus and a distinct nucleolus. This fact shows that not all of the cellular inclusions of the germarium go into the formation of ovarian eggs.

The data I have so far obtained in my work point to the following considerations:

1. Following the differentiation of the definitive terminal chamber, or germarium, in the embryonic mother, the cellular elements inclosed within it are similar to each other in size, shape, and structure.

2. These cells increase in size and, at a later stage in development, a few that are located in the posterior portion of the germarium exhibit a marked difference in structure from the rest of the cells.

3. At the termination of the period of fecundity of the mother, that is, when the eggs cease to be extruded from the germarium, a large number of the original cellular inclusions, probably about

twice those that have been extruded as ovarian eggs, remain within the chamber.

From a correlation of the foregoing three points, it seems justifiable to offer the following interpretations: The germ cells, by the time they are first inclosed by the walls of the definitive terminal chamber, have probably developed as far as the ultimate, or secondary, oögonia. This supposition is based on the fact that, after this stage, no further oögonial division has been found to take place. They are all similar in size and in cytological characters, and are apparently in a resting condition. Later, however, after increasing considerably in volume in common with all the rest within the chamber, the cells in contact with or in the immediate neighborhood of the formative egg follicle begin to enter into a period of growth or pass into the early prophase of the first maturation (?) division, in the manner which I have described above. A similar behavior of the posterior cells has been previously reported by Stevens (1905). The cells apparently remain in this condition, without increasing any further in volume, until after extrusion into the vitellarium. The earliest manifestation of this growth or mitotic activity apparently represents the transition of the cells from ultimate oögonia into oöcytes. The latter develop successively from the oögonia, and are extruded from the germarium, one after another, until a maximum limit of about nine eggs, or a total of one hundred eight eggs in the twelve vitellaria, is reached. The maximum number is probably determined by the ability of the mother to nourish the rapidly developing embryos directly from her own body fluid,[14] for viviparous reproduction undoubtedly saps the vitality of the mother to the extreme.

Although the cells which remain behind within the vitellarium at the conclusion of the period of fecundity may, from the beginning of ovulation, have possessed a secretory function which contributes to the nourishment of the developing eggs, it would not be correct to regard them as nurse cells, sui generis, homologous to the aggregation of cells known by that name in amphigonous aphid individuals. In the latter case, the nurse cells are actually differentiated, as such, since the early stages of definitive egg formation, although these nurse cells arise from the primitive germ cells, in common with the eggs. After differentiation, however, their structural changes become so great that the nurse cells lose their original egg-forming potentiality. On the other hand, in the case of parthenogenetic aphids, we have within the germarium a mass of cells that are apparently similar to one another in structural characters at all times. They probably are all formative ovarian eggs, the potentiality of which is not lost through further specialization, the individuals among them that proceed in development being controlled numerically by the physiological limitations of the mother. The extra number present in the germarium probably represents a reserve supply from which additional ones may be drawn when necessary. While these supernumerary oögonia are in their resting condition, they probably produce secretions which, together with the secretion from the egg follicle, nourish the developing egg. A somewhat similar idea has been previously suggested by Mordwilko (1907). It may be mentioned in this connection that I have so far failed to find the "central rachis" of Will and the "nutritive string" in any of the material I studied, although I looked for them particularly, both in sections and in fresh preparations. None of the cellular inclusions of the germarium have been found by me to be pedunculated, either, for they are all subpolygonal and resemble each other, except that those which I have interpreted as ultimate oögonia in the anterior portion of the chamber are in a resting state, while the oöcytes at the posterior portion are either in a period of growth or in early prophase.

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[14] This idea has been suggested to me by Prof. W. E. Castle, to whom my thanks are due.

It should also be noted at this juncture that the old view of Claus (1864, p. 44) and of Lubbock (1857), that the eggs of parthenogenetic aphids, as well as the "nurse cells," arise as a modification of the follicular epithelium, which was adopted with slight modification by Tannreuther (1907), is no longer tenable. The ultimate oögonia are present in large numbers in the germarium since the early differentiation of the latter. The oögonia, as their origin is generally considered by workers on different groups of animals, arise, not from the follicular epithelium, but from the primitive germ cells, which are segregated some time during the earlier stages in the development of the egg.

SUMMARY AND CONCLUSIONS

1. The follicular epithelium of the egg arises from a mass of rather large cells, adjoining the posterior end of the germarium. This tissue is present in this region since the early differentiation of the definitive terminal chamber. On the basis of its subsequent history, I am referring to it as formative egg follicle.

2. The formative egg follicle acts as a matrix, which, by its posteroanterior circumcrescence, provides the developing oöcyte with follicular epithelium.

3. The portion of formative egg follicle which closes over the anterior pole of the egg proliferates, until a thick, multilaminar layer is formed. This new layer replaces the original matrix, and the process of formation of the egg follicle around each succeeding egg is repeated.

4. The remnants of the matrices of the egg follicle persist as a posterior peduncle connecting the egg chamber with the contiguous one. The peduncle persists for a time; then it apparently ultimately degenerates, or is absorbed by the egg follicle proper during the stretching of the latter, thus finally leaving the neighboring egg chambers free from each other.

5. The peduncle probably supplies the egg with nutritive material, in common with the egg follicle proper, in addition to serving as a cushion between every two egg chambers and as storage tissue for the "symbionts" for the future infection of the egg.

6. After the definitive differentiation of the germarium, the cellular elements inclosed within its chamber apparently represent ultimate, or secondary, oögonia.

7. The oögonia increase in size within the germarium and stretch considerably the enveloping wall of the latter.

8. At a later stage in development, the oögonia which are in contact with or in the immediate vicinity of the formative egg follicle enter a period of growth or pass into the early prophase of the first maturation (?) division. The beginning of growth or of early mitotic activity marks the transition of the cellular elements within the germarium from oögonia into oöcytes.

9. The oöcytes remain without proceeding further in their karyokinetic processes until some time after extrusion into the vitellarium.

10. The cells present in the germarium are apparently not differentiated into definitive nurse cells and definitive oöcytes, as certain authors have claimed, but are all unmodified, potential ovarian eggs.

11. The oögonia which develop into ovarian eggs are apparently numerically limited by the capacity of the mother directly to furnish nourishment from her body fluid.

12. The resting oögonia may, while in that state, have a secretory function, contributing to the nourishment of the developing egg.

13. A large number of supernumerary oögonia remain in the germarium at the conclusion of the period of fecundity of the mother. They probably represent a reserve supply, serving to insure the production of the largest possible number of offspring.

14. The oöcytes are not modifications of the follicular epithelium, as has been claimed by certain authors. They arise from the secondary oögonia which are already present in the germarium and which, as I shall attempt to show later, in turn, originate from the primitive germ cells.

DEVELOPMENT OF THE PARTHENOGENETIC EGG

MATURATION AND CLEAVAGE STAGES, WITH REMARKS ON EARLY INFECTION OF THE EGG BY THE "SYMBIONTS"

The early phases of oögenesis in parthenogenetic aphids have been the subject of extensive investigation by earlier workers, principally by Will (1883), Blochmann (1887), Petrunkevitch (1903), Stschelkanovzew (1904), Stevens (1905), Tannreuther (1907), and de Baehr (1920, and also earlier papers by the same author). As Blochmann (1887) has first pointed out in connection with *Forda formicaria,* the parthenogenetic eggs of aphids extrude only one polar body, similar to the condition which Weismann and Ishikawa (1888) have observed subsequently in the parthenogenetic eggs of certain rotifers and crustaceans. The zygogenetic ones, on the other hand, extrude two, in the same manner as the eggs of other amphigonous animals. Further, he discovered that the parthenogenetic eggs of aphids retain the somatic number of chromosomes, in a manner which has been variously explained. In regard to this point, there are two principal views, which are essentially the same, except in the details: (*a*) That of Stevens (1905), who claims that in the parthenogenetic aphids there is but "one maturation division without reduction," and (*b*) that of de Baehr (1920), whose contention is that—

> les oöcytes de l'*Aphis palmæ* montrent encore à la prophase de maturation * * * des tendances hétérotypiques bien nettes, et c'est seulement à la diacinese, par la dissociation des gemini en leur composants (les chromosomes simples), qu'ils retournent a la mitose somatique.

This question, which needs further cytological investigation, falls outside the scope of the present paper.

The development of the oöcyte from the oögonium has been described above. As I have already shown, during the posteroanterior circumcrescence of the formative egg follicle around the oöcyte, the latter retains its direct communication with the terminal chamber for a time, before the complete closure occurs. In the meantime, the oöcyte increases considerably in size, so that by the time it is completely inclosed by the egg follicle (Plate 3, fig. 23, *ov*), it has grown to several times its original size. The cytoplasmic layer is finely granular, and stains rather deeply in Ehrlich's acid hæmatoxylin. The nucleus, which is located centrally in the ovarian egg,[15] has also grown considerably larger and is apparently vesicular, with a few loosely joined chromatin granules arranged in a subcentral position. The increase in size of the ovarian egg is probably partly due to growth of the cell itself and partly to deposition in the cytoplasmic mass of reserve food material, which, as has been suggested by Wheeler (1889) in connection with *Blattella germanica,* is "secreted by the protoplasm of the epithelial cells, not as yolk, but as substances taken up by the growing ovule." A part of this protovitelline material, in aphids, probably originates also from secretion of the cellular inclusions of the germarium during the time that the formative egg follicle has not yet completely inclosed the ovarian egg.

Before extrusion of the polar body, the ovarian egg of *Macrosiphum tanaceti* is subellipsoidal, and is longer anteroposteriorly than laterally. It attains a maximum length of about 25 micra and cross-sectional diameter of about 17 micra. The subglobular nucleus is about 9 micra in diameter, with a few scattered chromatin granules which are not sharply defined in outline. An egg in that stage is shown in Plate 3, fig. 25. The follicular epithelium, which is not shown in the figure, is closely applied around the egg. It is unilaminar and measures about 1 micron in thickness, except at the anterior and posterior poles, where it is stratified, with a corresponding measurement of about 3 micra.

Soon the nuclear membrane of the ovarian egg disappears, and the nucleus undergoes mitosis. At the same time, numerous vacuoles which have concentrated together and formed a cytoplasmic network appear posteriorly and laterally near the nucleus, leaving a thick, irregularly shaped cytoplasmic mass in which mitosis takes place. A thick, peripheral cytoplasmic layer, which apparently represents the early formation of the so-called Keimhautblastem (Weismann, 1864, p. 5), periplasm, or perivitellus (Korschelt and Heider, 1899, p. 262), bounds the cytoplasmic network ectally. As has been suggested before by Blochmann (1887) and by Stevens (1905), the network apparently contains yolk, which is not easily distinguishable in either the fresh material or in sections because of its scarcity, the small size of the globules, and also the fact that it is probably dissolved out by the histological reagents used.

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[15] The oöcyte at this stage of growth is usually termed "ovarian egg." (Sharp, 1921, p. 221.)

The nucleus at this stage is eccentrically located, toward the anterior pole of the egg. Plate 3, fig. 26, shows the nucleus in late anaphase, in that position. The cleavage plane is subperpendicular to the longitudinal axis of the egg. This condition apparently represents the extrusion of the only polar body. At the conclusion of telophase, the daughter nucleus which is located posteriorly becomes entirely isolated, together with a layer of enveloping cytoplasmic mass, from the periplasm through the anterior extension of the cytoplasmic network. The slender cytoplasmic strands of the network serve as connecting bridges between the centrally located nucleus and the periplasm. The polar body, which remains within the periplasmic mass, probably disintegrates after a short time. I have never had occasion to observe the polar body in any of the parthenogenetic aphid eggs I have studied, and my failure to do so is probably due to this rapid disorganization.

Plate 3, fig. 27, shows an egg after the extrusion of the polar body has taken place. The egg is irregularly subglobular, greater in lateral than in anteroposterior diameter, and measures about 30 by 24 micra. The nucleus is more uniformly subglobular, measuring about 9 micra in diameter, and is somewhat eccentrically located in the egg. The chromatic network is very open, so that the nucleus appears vesicular, with a few small, faintly staining chromatin granules. There is an enveloping thin, irregular sheet of finely reticular cytoplasm which connects radially with the strands of the surrounding cytoplasmic network. The periplasm covers the entire periphery of the egg, and is of variable thickness.

In the first cleavage, the poles of the mitotic spindle are directed anteroposteriorly, almost in the same direction as the longitudinal median axis of the egg. The egg at this stage (Plate 4, fig. 28) is subglobular, with a diameter of about 30 micra. The cleaving nucleus is somewhat eccentric in its location in the egg, and is separated from the periplasm by the intervening cytoplasmic network, as in the previous stage. The periplasm continues to cover the entire periphery of the egg.

By the conclusion of the first cleavage, the egg has elongated anteroposteriorly into a narrowly subellipsoidal form, and the two daughter nuclei are found each toward one of the poles (Plate

4, fig. 29). The egg at this stage is about 43 micra long and 23 micra in its greatest diameter. The cleavage nuclei are subglobular and measure about 8 to 9 micra in diameter. A few minute chromatin granules are sparsely scattered in the faintly staining karyolymph. The periplasm still persists at the entire periphery of the egg. The follicular epithelium is detached from all the sides of the egg, except at the posterior pole, with which it is still closely connected.

After this stage, all the daughter nuclei appear to undergo mitosis, simultaneously at first; later, however, they do not all divide at the same time.

It is interesting to consider at this juncture the marked changes in the shape of the egg during the earlier cleavage stages. We have noted that prior to the extrusion of the polar body the egg presents an abruptly subellipsoidal aspect. This shape persists until after the completion of the process, the egg then exhibiting only an increase in size. It then assumes a subglobular form, until first cleavage, when it begins to elongate again anteroposteriorly into a subellipsoidal form, this time more narrowly so. I take these abrupt changes in shape to be due to a rapid progressive increase in the volume of the egg, as a result of further vacuolation in the cytoplasmic mass and consequent increase in size of the cytoplasmic network. The force of expansion within the egg accompanying such active vacuolation changes from one direction to another, being alternately greater anteroposteriorly than laterally, and vice versa.

The periplasm persists at the entire periphery of the egg even to the two-nuclei stage. Later, however, a direct communication is established between the cavity occupied by the cytoplasmic network in the interior of the egg and the follicular epithelium by the disappearance of a portion of the periplasm from the posterior pole. Plate 4, fig. 30, represents an egg with at least four cleavage nuclei, in anaphase. At the posterior pole there is very marked vacuolation and thinning of a small portion of the periplasmic sheet. This condition apparently represents the initial steps in the removal of the cytoplasmic layer from this region.

In the same figure, the migration of the cleavage nuclei into the periplasm is illustrated. Upon coming in close proximity to the latter, the cytoplasmic layer enveloping the cleavage nucleus coalesces with the periplasm. The substance in the two masses being apparently identical, the cytoplasmic envelope of the cleavage nucleus becomes absorbed as an integral part of the periplasm. The nucleus is then drawn more deeply into the thick cytoplasmic sheet, probably by surface tension in the latter, and in this way becomes embedded in the periplasm. The relation of the cleavage nuclei to the periplasm at this early stage has apparently no morphological significance, for there is evidently a tendency to return to the cytoplasmic network in the interior of the egg, at least in the case of some of the nuclei.

Earlier workers on aphid embryology have ascribed a great deal of importance to the question of whether in these earlier cleavage stages some of the nuclei lag behind and become predestined as "vitellophags," or whether all of the nuclei become embedded ultimately in the periplasm, the "vitellophags" arising as a result of later immigration from the periphery. Witlaczil (1884) claims to have observed the first condition, and he has been supported in this view by Stevens (1905) and by Tannreuther (1907). Will (1883), on the other hand, takes the opposite view, maintaining that all of the cleavage nuclei migrate to the periplasm. In a more recent paper Hirschler (1912), after giving a concise review of the subject, justly expresses his disagreement with all of his predecessors. I am quoting this author at length on account of the bearing of his remarks on the present question:

> Ich möchte nämlich den gegen die Eimitte vorgerückten Kern für einen Abkömmling des central im Ei gelegenen Furchungskernes des zweizelligen Stadiums ansehen, wobei der zweite an die Peripherie gerückt ist. Es scheint mir nun im allgemeinen berechtigt, angesichts dessen, das in manchen Fällen einer der zwei Kerne central gelegen und dass im vierzelligen Stadium wiederum oft ein Kern mehr centralwärts gelagert ist, anzunehmen, dass bei *Rhopalosiphum* nicht immer alle Kerne an die Peripherie gelangen, sondern dass auch hier, wie bei den meisten Insekten, Furchungsproducte im Eiinnern zurückbleiben. Merkwürdig könnte hier vielleicht dies erscheinen, dass bei ein und derselben Art die Furchungskerne ein verschiedenes Verhalten aufweisen, dem gegenüber wäre zu erwähnen, dass die dotterarmen, kleinen Aphideneier eben zur Feststellung dieser Varianten sich vorzüglich eignen, während dieselbe, bei den dotterreichen, grossen Insekteneiern erheblich erschwert wird, wodurch auch die bezüglichen Vorgänge noch immer nicht genügend in ihren Einzelheiten bekannt sind. Anderseits wäre auch hervorzuheben, dass die Kleinheit der Aphideneier das bestehen solcher Varianten begünstigt, denn auch ganz geringe Kernverschiebungen, die in den grossen Insekteneiern oft nur unter geordnete Differenzen hervorbringen könnten, verursachen bei den ersteren schon ziemlich grosse Entwicklungsvarianten. Angesichts dessen nun, dass die Entwicklungsvarianten durch die Kleinheit der Eier begünstigt, letztere aber durch die Dotterarmut, die wiederum höchst wahrscheinlich mit der sekundär erworbenen Viviparität im Zusammenhang steht, verursacht wird, möchte ich ihnen keinen grösseren morphologischen Wert zuschreiben.

My own observations are in accord with those of Hirschler in that migration of the cleavage nuclei into the periplasm apparently occurs soon after the first cleavage. I have never observed in my material any instance in which, after the first cleavage, one of the daughter nuclei, as he claims, migrates to the periphery, while the other lags behind within the cytoplasmic network. I did find, however, that after the second cleavage (Plate 4, fig. 30) three of the daughter nuclei are embedded in the periplasm while one is isolated by the cytoplasmic network. His contention that the two opposite points taken up by the earlier authors have no morphological value seems to be tenable, on the basis of the reasons he has given. Following this question further, I may add that, during the earlier stages in the development of the egg, there is a period in which an active shifting and reshifting of the cleavage nuclei from one part of the egg to another apparently takes place. Whether this movement of the cleavage nuclei is due to their own activity, in which the pseudopodialike projections from the surface of their enveloping cytoplasm play a part, or whether they are transported mechanically by the cytoplasmic stream of the egg has not been satisfactorily determined. As a result of these movements, certain nuclei come in contact with the ental surface of the periplasm and become embedded in the latter, in the manner I have described. During the earlier cleavage stages the latter process is not necessarily an expression of the initial steps in the organization of the blastoderm, for there are many cases in which the nuclei soon dissociate from the periplasmic layer and return to the yolk mass. It seems to be more reasonable to consider the nuclei in these earlier stages, as represented in Plate 4, figs. 29, 30, 31, and 32, as plastic units, all of which are potential blastomeres—conditional upon their finally remaining in the periplasm—but the ultimate destiny of none of which is definitely predetermined. During these plastic stages, all the nuclei in the developing egg, at one time or another, apparently have some relation with the function of converting the protovitelline material in the cytoplasm into yolk. The formation of vacuoles in the cytoplasm is apparently caused by the deposition of yolk in small separate masses. That the activity of the cleavage nuclei is apparently responsible for this process is indicated by the suspicious relation of the appearance of the earliest cytoplasmic network in the egg with the first mitotic phases accompanying the extrusion of the polar body.

Soon, however, a state of equilibrium is reached when the apportionment of the cleavage nuclei into two definitive sets takes place, as follows: (*a*) The nuclei which ultimately remain in the cytoplasmic network, and continue the earlier common function of all the cleavage nuclei—the elaboration of food material. They are in this respect homologous to the "vitellophags" of other insect eggs. However, they represent the progenitors of the cells which ultimately compose the "mycetom." For this reason, I shall refer to these yolk nuclei of aphids as "mycetoblasts." (*b*) The nuclei which definitely remain embedded in the periplasm and ultimately give rise to blastomeres. Plate 4, figs. 33, 34, and 35, show three consecutive stages during the primary differentiation, which I have spoken of above. In fig. 33 the nuclei which have migrated to the periphery (*fb*) apparently remain embedded in the periplasm. Two of the "mycetoblasts" (*mb*) are shown. In fig. 34 the formative blastomeres have increased considerably in number, by tangential division, so that they are arranged much more closely to one another than in fig. 34. This closeness of the nuclei may be due also to an anteroposterior compression which results from the noticeable shortening of the egg at this stage. The "mycetoblasts" are apparently arranged sublinearly along the longitudinal axis of the egg. Figure 35 shows some of the nuclei in the periplasm and two of the "mycetoblasts" in mitosis. As may be judged from the figure, division does not occur synchronously in all the nuclei.

An earlier part of the present account has left the periplasm still covering the entire periphery of the egg. Mention has already been made of the fact that in Plate 4, fig. 30, which represents an egg undergoing third cleavage, the periplasm at the posterior pole has been reduced to a comparatively much thinner sheet than the rest and shows signs of active vacuolation. This condition apparently represents the initial steps in the formation of the opening of the periplasm at the posterior pole of the egg. The process of removal of the cytoplasmic layer from this region apparently occurs rather rapidly, the vacuoles soon expanding, and reducing the cytoplasmic sheet into an open network, in common with the rest in the interior of the egg. In this way the opening of the posterior pole is established.

It should also be noted that, as shown in Plate ~~5,~~ 4 fig. 29, while the egg is in the two-nuclei stage and the posterior opening of the periplasm has not yet formed, the follicular epithelium becomes detached from around the entire periphery of the egg, except at the posterior pole, where it remains intimately in contact with the surface of the egg. The follicular epithelium at this region exhibits considerable thickening in a portion contiguous to the posterior peduncle of the egg chamber (not shown in figure).[16] This thickening indicates that, even before visible signs of vacuolation appear, diffusion of yolk mass from the interior of the egg to the egg follicle probably occurs.

The opening of the periplasmic wall at the posterior portion of the parthenogenetic aphid egg has been known for a long time. Will (1889) has described its presence, and given a detailed account of its significance. He has reported the incursion, through this opening, of "todte Nahrungsmasse" which originates from the follicular epithelium and gives rise to the "pseudovitellus." He refutes, correctly, the older views of Metschnikow (1866) and of Witlaczil (1884), both of whom have claimed that the "pseudovitellus" arises directly from the follicular epithelium, by migration of nuclei from the latter into the interior of the egg. Will did not even suspect the relation of the "vitellophags" ("mycetoblasts") to the subsequent history of the "mycetom," for he is sponsor to the idea that they enter into the formation of the mid-intestine. The incursion of the "symbionts" from or, rather, through the follicular epithelium, in coccids as well as in aphids, has been reported by Šulc (1910), Pierantoni (1910, 1914), Buchner (1912, 1921), Shinji (1919), and others. The most generally admitted view is that the follicular epithelium has something to do with the introduction of the "organisms" into the developing egg, although no very definite theory in regard to the actual source of infection has been proposed, except the one by Will, which I have already mentioned; that of Šulc (1910), who reports that in

> *Aphis amenticola* Kaltenbach (?) habe ich an den unteren Polen der ganz jungen Eiern, wo vom Pseudovitellus noch keine Spur war, äusserlich unsere Hefe frei kleben gesehen; sie mussten also auf welche Art die Mycetocyten, auf welche sie sonst angewiesen sind verlassen haben und schickten sich zum Eindringen in das Ei zwischen den interzellulären Räumen der Zellen des Eifaches,

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[16] A somewhat similar condition has been noted previously by Balbiani, as is evident from one of his figures. See Henneguy (1904, p. 405, fig. 395, A, f).

which observations have not been confirmed by subsequent investigators, and with which the results of my work also disagree;[17] and that of Buchner (1921), in which he or, rather, one of his students, claims to have seen a cell from the "symbiotic" organ of the mother in contact with the ovariole. Through an elaborate entrance in the follicular epithelium, guarded by some five nuclei, in a manner somewhat similar to that previously described by Stevens (1905), Buchner has made the "mycetocyte" pour into the egg its cell-full of "symbionts." Since the publication of Buchner's book, I have reëxamined my slides of *Macrosiphum tanaceti* for confirmation of this report. I have so far failed to find such an arrangment, and probably never shall find it. It does not seem probable that the mother would expend her "symbiotic" cells, one after another, to supply her many young which, as I have stated before, reach a total of at least one hundred eight, and have enough to supply all of them, to say nothing of the part of the organ that she apparently requires for the use of her own body. I have dissected numerous aphids in both the nymphal and the adult stages, and found that the number of cells composing the "symbiotic" organ ranges from about sixty to about seventy only; I have never found a higher figure. Flögel (1905) has discovered that, after birth of the aphid, the "mycetom" cells no longer divide but merely increase in size. My own observations have confirmed Flögel's results. This condition means that, from this limited supply at her disposal, at least in the species I have worked with, the parthenogenetic aphid mother could not have provided for all her embryos, each requiring one "mycetom" cell, if Buchner's contention were true.[18]

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[17] It is highly probable that the "yeasts" which he has found free at the posterior pole of the young egg arise from infection from the swollen portion of the egg follicle. As I have described elsewhere in the present paper, the "organisms," lodged in the egg follicle, apparently begin to become activated by the egg yolk which diffuses to the latter even before vacuolation in the periplasmic layer at the posterior pole of the egg becomes evident. The rapid multiplication of the "symbionts" resulting from this stimulus causes an incursion of these "organisms" into the egg.

[18] There are, in addition, the views of Metschnikow, of Balbiani, and of other older authors, which in the light of our present knowledge of the subject are obviously unacceptable.

Will's earlier view, that the mass of granular material which enters in the formation of the "pseudovitellus" originates from the follicular epithelium, appears to be more acceptable. His contention that the granular mass is "todte Nahrungsmasse," of course, no longer holds. Emeis (1915), working on coccids, has reported similar behavior of the "microörganisms" in this group of insects. In my own work there is, it seems to me, sufficient evidence to justify the statement that "symbionts" are present also in the egg follicle of aphids.

Some time before any sign of vacuolation appears in the periplasm at the posterior pole of the egg, the part of the follicular epithelium which is closely applied to this region shows considerable thickening, which I have noted above. Upon completion of the opening of the periplasm, the swelling of the contiguous follicular epithelium becomes much more pronounced (Plate 4, fig. 32). In fresh preparation, I have observed within the meshes of the cytoplasmic network immediately adjacent to the follicular epithelium a diffuse greenish mass of granules which apparently enter the opening of the periplasm from the follicular epithelium. This migrating mass, as will be seen later from its subsequent history, represents a mass of "symbiotic organisms."[19] The "organisms" are apparently present in the follicular epithelium, mainly in the posterior peduncle, as I have stated before. They probably are in a dormant condition. When the egg yolk is made available to them through the disappearance of the intervening periplasmic layer from the posterior pole of the egg, they apparently become activated, causing them to multiply very rapidly. This rapid multiplication results in a swelling of the follicular tissue, which grows considerably larger during the later developmental stages of the egg, as may be judged from Plate 7, fig. 45, *fe*. The posterior swelling appears as a subhemispherical protuberance, which is closely applied against the opening of the periplasm and is separated from the base of the posterior peduncle only by a shallow depression. Such an arrangement is much more readily observable in whole mounts of ovarioles. The appearance of a separate swelling in the follicular epithelium suggests that the source of infection is not directly from the posterior peduncle, but from the contiguous cells in the follicular epithelium proper.

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[19] In all my figures, with the exception of those in Plates 1 and 2, the "symbionts" are represented by red stippling.

The peduncle, with its large store of "organisms," probably acts as a dispenser, which continually supplies them to the egg follicle proper, since the latter, on account of its relatively much thinner wall, harbors only a very limited number of "symbionts."

The cells of the egg follicle apparently rupture and cause an incursion of the "symbionts" into the egg, these "organisms" perhaps being attracted by the egg yolk. The greenish color, which is also present as minute granular, apparently chlorophylloid, matter [20] in the "organisms" within the definitive mycetocytes of the older embryos and subsequent stages, is presumably a manifestation of metabolic activity. Hence, no color is noticeable in the "microörganisms" which are probably dormant in the follicular epithelium, before the latter comes in contact with the egg yolk.

After incursion of the "symbionts" into the interior of the egg, they remain aggregated within the posterior third of the latter, in a more or less diffuse mass. The "mycetoblasts," which are arranged sublinearly along the longitudinal median axis of the egg, now tend to collect within the "symbiotic" fluid, so that, as shown in Plate 5, fig. 36, *mb*, they crowd together into the posterior half of the cavity of the egg, a few of them even migrating far outside the opening of the periplasm, toward the swollen follicular epithelium, where the mass of "symbionts" is presumably more concentrated. The proximity of some of the migrating "mycetoblasts" to the egg follicle is probably responsible for the erroneous interpretation by some of the earlier workers, and comparatively more recently by Tannreuther (1907), that the "pseudovitellus" arises by direct incursion of cells from the egg follicle.

The relation of the "vitellophags" to the "symbiotic" bodies was suggested years ago by Wheeler (1893). He regards them as "considerably specialized" nuclei, with "limited function and mobility," and "suspicious relations to the bacteria-like corpuscles of Blochmann."

My own observations agree in a general way with Pierantoni's (1914) account in connection with *Icerya purchasi* Maskell (Coccidæ). This author gives the following summary of his findings:

> Durante la formazione del blastoderma si costituiscono anche le cellule proprie dell'organo simbiotico * * * [il quale] hanno origine da blasto-

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[20] The coloring matter of the "symbionts" disappears very rapidly in alcoholic media.

meri interni che vanno ad involgere la massa polare, e che hanno valore e costituzione simile alle cellule vitelline.

The attraction of the "mycetoblasts" to the mass of "symbionts" appears to be analogous to phagocytosis. This fact suggests that the granular bodies coming into the egg from the follicular epithelium probably represent foreign protein. Such a condition very strongly supports the idea that these granules are really not by-products of the insect's own metabolism, but apparently extraneous organisms.

There is one other interesting fact in connection with the cleavage stages. Shortly before differentiation of the definitive blastomeres, a much more pronounced mitotic activity occurs among the nuclei in the periplasm at the anterior pole of the egg than in other regions. As a result of this division, a number of small nuclei (Plate 5, fig. 36, *b*) is extruded entally. These secondarily migrating nuclei are only about one-half the size of the "mycetoblasts." On account of their diminutive size, they have been mistaken for degenerating bodies. Witlaczil (1884) has erroneously interpreted them as disintegrating "vitellophags," and this view has been adopted by later workers, notably by Buchner (1921) and his student. As I have already shown, the "vitellophags" in aphids, or what I have called the "mycetoblasts," enter ultimately in the formation of the "mycetom." The smaller nuclei could hardly be considered as degenerating, for many of them are found in mitosis. An attempt is being made in a later discussion to trace their subsequent history.

SUMMARY AND CONCLUSIONS

1. By the time the egg follicle closes over the anterior pole of the ovarian egg (oöcyte during growth period) the latter has increased to several times its original size, partly by growth of the cell itself and partly through accumulation in its cytoplasm of reserve food material.

2. The reserve food material probably arises from secretions of the egg follicle, as well as from those of the cellular inclusions of the germarium.

3. Maturation is completed after the egg is completely inclosed by the egg follicle. The polar body is extruded into the periplasm at the anterior pole of the egg. The cytoplasmic network, which presumably contains yolk globules in sparse amounts within its meshes, begins to appear at the same time. The formation of this network is apparently correlated with the

activity of the nucleus, which fact indicates that the latter probably plays an important part in the elaboration of protovitelline substance into yolk.

4. Soon after extrusion, the polar body apparently degenerates very rapidly in the periplasm.

5. At the conclusion of the polar-body extrusion, the other daughter nucleus becomes surrounded with cytoplasmic network, completely isolating it from the periplasm, except for the connecting cytoplasmic strands.

6. Mitosis occurs simultaneously during the first few cleavage stages; but this regularity soon ceases.

7. Abrupt changes in the shape of the egg occur, from subellipsoidal before and during the extrusion of the polar body, to subglobular-discoidal before first cleavage, to subglobular during first-cleavage mitosis, and to narrowly subellipsoidal after first cleavage. After the last-named stage, the egg remains more or less subellipsoidal. The abrupt changes taking place during the earlier stages apparently result from an active formation of additional vacuoles, which join the cytoplasmic network. The force of expansion in the formation of these vacuoles is probably exerted with greater power alternately, in one direction first and then in another within the egg.

8. During the earlier stages in the development of the egg, the cleavage nuclei are apparently plastic units, the ultimate destiny of none of which is definitely predetermined. There seems to be a continuous shifting and reshifting of the cleavage nuclei at this stage, and whatever position they may then assume with respect to the periplasm and the central yolk mass is not necessarily an expression of initial steps in the subsequent organization of the egg. A return of the cleavage nuclei into the yolk at this time, after having become temporarily embedded in the periplasm, has presumably no morphological significance.

9. During these earlier stages, all the cleavage nuclei, at one time or another, act as vitellophags. Each is apparently a potential blastomere, conditional upon its ultimately remaining imbedded in the periplasm.

10. A state of equilibrium is soon reached when the apportionment of the cleavage nuclei into definitive formative blastomeres and definitive vitellophags takes place.

11. The vitellophags show a marked attraction to the mass of "symbiotic organisms" which invades the egg through the

posterior pole. On account of their ultimate destiny as formative "mycetom," I have adopted the term "mycetoblasts," in place of "vitellophags."

12. The affinity of the mycetoblasts to the mass of "symbionts" is very suggestive of the behavior of leucocytes in the presence of foreign protein (phagocytosis), indicating thus that these supposedly extraneous "microörganisms" are probably really such, and not by-products of the insect's own metabolism.

13. The periplasm at first forms a continuous layer at the entire periphery of the egg. Soon an opening appears at the posterior pole of the latter through the periplasmic wall.

14. The opening through the periplasmic layer arises through active vacuolation of its cytoplasmic mass, resulting in the formation of a network which becomes continuous with the similar structure in the interior of the egg.

15. At about the second-cleavage stage, the follicular epithelium becomes detached from the surface of the egg, except at the posterior pole, with which intimate contact is retained.

16. The follicular epithelium apparently harbors "symbiotic organisms," particularly in the posterior peduncle of the egg chamber, which I have previously described.

17. The formation of the opening through the periplasmic layer is evidently a special provision for the entrance of the "symbionts" into the egg.

18. The periplasmic opening arises at the region where the egg follicle remains in intimate contact with the posterior portion of the egg. This fact suggests that the opening is probably induced by secretions from the "symbionts" in the follicular epithelium.

19. The egg follicle swells considerably at the point of contact with the egg, especially when the vacuolation of the periplasmic wall begins to become noticeable.

20. The swelling lies contiguous to the posterior peduncle of the egg chamber. The latter probably acts as a dispenser of "microörganisms" to the egg follicle which, on account of its relatively thinner wall, harbors a limited supply.

21. The swelling presumably results from the activating effect of the egg yolk on contact with the "symbionts," when the periplasmic barrier is removed, resulting in a stimulation of the "organisms" to multiply with increased rapidity.

22. The mass of "symbiotic organisms" presents a greenish hue, owing to its apparently chlorophylloid, intracellular, gran-

ular inclusions. The appearance of these granules is apparently a manifestation of active metabolic processes. No green color is evident in the "microörganisms" which are presumably dormant in the follicular epithelium before this comes in contact with the egg yolk.

23. Shortly before the differentiation of the blastoderm, a few nuclei, somewhat smaller than the "mycetoblasts," migrate from the periplasm at the anterior pole of the egg into the egg cavity. These small nuclei divide actively by karyokinesis and are, therefore, not degenerating bodies.

BLASTODERMAL DIFFERENTIATION AND SUBSEQUENT STAGES, PRIOR TO METAMERIC SEGMENTATION OF THE GERM BAND

At about the time of differentiation of the blastoderm, the egg (Plate 5, figs. 36, 37) is subellipsoidal and measures about 60 micra in length and 30 micra in greatest cross-sectional diameter. The periplasm remains in the same condition as that described in the later cleavage stages: it forms a continuous dense layer at the entire periphery of the egg, except at the posterior pole, where an opening allows free communication between the part of the follicular epithelium adjoining that region and the interior cavity of the egg. The periplasmic layer apparently foreshadows the future position and extent of formation of the blastodermal wall.

The cleavage nuclei embedded in the periplasm are arranged much more closely together, on account of their greatly increased number. They are subglobular, and measure about 5 micra in diameter. A few deeply staining, large, irregular chromatin granules are present in the clear karyolymph. Mitotic figures are found, especially at the anterior pole of the egg.

The "mycetoblasts" are still in progress in their migration toward the posterior half of the egg, where they are apparently attracted by the inflowing mass of "symbionts." I judge, from their relatively larger number at a subsequent stage, that these nuclei must divide rather actively at about this time, although I have not found mitotic figures among them in the material I have on hand.

The small anterior nuclei, which I have described before as resulting from a secondary migration from the periplasm into the anterior portion of the egg cavity,[21] have also increased markedly in number, although they never become so numerous as the "mycetoblasts." Figure 36 shows the characteristic relative position which the "mycetoblasts" and the small anterior nuclei assume at this time. Figure 37 represents an apparently aberrant case, in which the "mycetoblasts," of which only three of the anterior ones are shown, are slow in migrating toward the posterior portion of the egg; they are still arranged in a sublinear position, as I have described in some of the earlier cleavage stages. The small anterior nuclei, which are present in the other sections of the series, are not in evidence in this particular one. The figure is intended primarily to show the manner in which the blastomeres are formed.

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[21] These nuclei will be referred to hereafter as "small anterior nuclei." No definite name can be assigned them, on account of their doubtful ultimate destiny in the later developmental stages of the embryo.

The differentiation of the definitive cell territories of the blastoderm occurs by a simultaneous constriction of the periplasmic layer, between the nuclei. Such a condition represents a much simpler case than the relatively more complicated process described by Weismann (1882) in *Chironomus,* by Blochmann (1887) in *Calliphora* (= *Musca*) *vomitoria* Linn., and by Heider (1889) in *Hydrophilus.* In these groups, there occurs in the periplasmic layer, between the nuclei, a surface furrowing which progresses entally until the complete lateral cell boundaries are marked out. In the meantime, a secondary "Keimhautblastem," which is devoid of nuclei, appears beneath the first. The furrows mentioned above continue through to the ental surface of the underlying layer, which results in the latter being added to the height of the blastomeres.

Some of the earlier blastodermal stages in parthenogenetic *Macrosiphum tanaceti* are shown in Plate 5, figs. 38 and 39, and Plate 6, figs. 40 and 41. The egg shown in fig. 38 represents a stage in which the blastoderm has just been completed. It is about 60 micra long and 30 micra in greatest cross-sectional diameter. These measurements are practically identical with those of the latest cleavage stages described above, a condition which points to the fact that the transition from a syncitial stage of the nuclei in the periplasm to the differentiation of the definitive blastomeres is accompanied by no appreciable increase in the size of the egg. At this relatively early stage, the unilaminar structure of the blastodermal wall is still in evidence. The wall covers the egg at the regions where the periplasm has been located previously, and is somewhat thicker at the anterior pole, whence it gradually attenuates posteriorly to the rim of the opening, which is now the "blastopore."[22] The blastomeres are relatively large, somewhat columnar cells, showing only slight signs of lateral compression, as a result of mutual pressure. The nuclei are subellipsoidal or subglobular, measuring from about 5 to about 7 micra in diameter. One noteworthy point relative to the blastodermal wall at this early stage is that it extends only to about three-fourths the total length of the egg chamber (compartment inclosed by the egg follicle), leaving the posterior one-fourth free.

The "mycetoblasts" are about 6 to 7 micra in diameter. Their aggregation occupies more than one-half the blastocœle, and extends posteriorly outside the blastopore to the portion of the egg chamber which is free from blastodermal wall. The mass of "symbionts" which has come to occupy the meshes of the cytoplasmic network among the "mycetoblasts," where the "organisms" gradually appropriate the egg yolk, is still diffuse. The strands of the network join the "mycetoblasts," so that these nuclei are not actually free from each other, but are in syncytium.

An inflow of the "symbionts" from the follicular epithelium probably still takes place, although in much more limited quantities, on account of the fact that the "organisms" have increased so much in number in the egg cavity that a balance must have been almost established by this time. It is hard to account for the persistence of the swollen portion of the follicular epithelium, which continues to increase in size progressively with the succeeding blastodermal stages, even to the time when the formative "mycetom" is so far advanced in development that there could not possibly be any need for reënforcement from that source. One possible explanation is that the stimulus originally exerted by the egg yolk has so activated the "organisms" within the follicular epithelium that rapid multiplication in the latter continues for a long time afterward.

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[22] The term "blastopore" is used in this connection merely to indicate the opening of the blastocœle. Will (1889) has employed the same term in connection with his contention that at this stage in aphids a true gastrulation obtains, basing his arguments on the fact that the "vitellophags" (my "mycetoblasts") are, as he claims, of entodermal nature. On account of their very early segregation during the time that the cleavage nuclei are apparently still undifferentiated, even prior to the formation of the blastoderm, I cannot subscribe to Will's idea.

Hirschler's (1912) views also seem germane to the present question. He claims that the blastopore (in the sense in which I use the term) is either present or absent in aphids, depending upon the shape of the mass of "pseudovitellus." He says, in part: "In den Fällen wo der Pseudovitellus eine pfropfartige Form besitzt, könnte man die Blastula als am hinteren Eipole offen stehend betrachten, in allen andern, denen alle grossen Blastulae zuzurechnen sind, ist der Dotter allseitig mit Zellen bedeckt, eine Oeffnung ist nicht vorhanden." He attempts to show that Witlaczil's (1884) contention that the blastoderm grows over the entire surface of the egg, and that of Will (1889) and of Tannreuther (1907) that this structure covers only the anterior pole and the sides, leaving a blastopore at the posterior pole, are both correct. In my own work, I have only found the case where the mass of formative "mycetom" serves as a plug ("Pfropf") in the blastopore. I have never had occasion to see the other type.

The small anterior nuclei in the stage under consideration in the foregoing paragraphs measure about 3 micra in diameter. They are, of course, also in syncytium, in the cytoplasmic network within the very limited space in the anterior portion of the blastocœle. The "symbionts" apparently do not invade this region.

The formation of the "germ cylinder" through invagination of the blastopore has been described by earlier workers (Will, 1889; Tannreuther, 1907; Hirschler, 1912; et al.). Tannreuther claims to have observed that only the posteriorly located cells, at the rim of the blastopore, give rise to the invaginating cylinder, by proliferation. He has failed to note the fact however that, before invagination takes place, the blastoderm grows posteriorly and fills in the posterolateral gap in the egg chamber, which I have described above. In this way, the lateral sides of the mass of formative "mycetom" are almost completely covered by the blastodermal wall. The posterior extension of the blastoderm apparently results, not only from a multiplication of the cells at the rim of the blastopore, but also from a general division among the constituent cells of the entire blastodermal wall. At the conclusion of extension, the blastoderm (Plate 5, fig. 39, *bl*), in section, appears stratified, as a result of the very considerable increase in the number of cells which crowd together, particularly at the anterior pole. There is also a slight increase in the diameter of the egg.

The mass of formative "mycetom" at this time (Plate 5, fig. 39, *fm*) is irregularly subellipsoidal, completely occupying the posterior half of the total length of the blastocœle, which has become very much greater in diameter at this region. The formative "mycetom" now adjoins the follicular epithelium posteriorly and is closely applied to the ental surface of the blastoderm laterally. The anterior surface of the mass is sharply defined in outline with the small anterior nuclei, embedded in a dense cytoplasmic mass, contiguous to it. The formative "mycetom" now appears to be much more concentrated, apparently due to the increase in number of "mycetoblasts" present, and their gathering together more closely toward the posterior end of the blastocœle. The "symbionts" are also present in the mass in very much increased proportions, so that the strands composing the cytoplasmic network have become obscured by their presence.[23]

During the subsequent growth of the egg, the "germ cylinder" begins to invaginate, by proliferation of the cells at the rim of the blastopore. Plate 4, figs. 40 and 41, shows two successive stages in the process. In the former figure, there is no evident fundamental change from the previous stage, except for the invaginating blastodermal layer, which becomes closely applied entally to the mass of formative "mycetom." With the subsequent development of the "germ cylinder" (Plate 6, fig. 41, *cyl*) which is open at both ends,[24] the formative "mycetom" is pushed anteriorly as invagination progresses, so that the latter forms a subglobular mass pressed against the anterior end of the former. The swollen follicular epithelium at this stage has developed an anterior cup-shaped depression, the thin edge of which closely fits into the rim of the posterior opening of the cylinder. This structure apparently represents a persistence of the original intimate connection between the egg follicle and the surface of the egg at the posterior pole. After invagination of the cylinder, the pressure of the fluid (amniotic fluid) in its lumen, applied against the anterior wall of the follicular epithelium which is apparently still firmly united with that portion of the blastoderm in contact with it, probably results in this cup-shaped sagging.

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[23] The nuclei in syncytium in a vacuolated layer of cytoplasm which Buchner (1921), using an original drawing by one of his students, represents in his fig. 58b, page 213, as the anlage of the "mycetom," at a stage corresponding to the present one, has not been confirmed in my material. As I have noted above, the entire posterior half of the blastocœle, down to the adjoining follicular epithelium, is occupied by what I have interpreted as a mass of formative "mycetom," the origin of which I have traced from the "mycetoblasts" ("vitellophags") and from the "symbionts" that infect the egg from the follicular epithelium. In the same figure, Buchner has depicted the anterior half of what I have represented in the present paper as the formative "mycetom," as a detached, subglobular mass, which he interprets as the "primitive germ-cells." In their effort to localize the latter cells in this region, Buchner and his student have evidently fallen under the spell of the views of some of the older masters (cf. Henneguy, 1904, p. 405, fig. 395, A, h). The primitive germ cells, at least in the material I worked with, are not in evidence as a definite mass until the "germ-cylinder" is well formed. A fuller description of the first visible appearance of primitive germ cells is given in the text of the present paper.

[24] This condition has been reported first by Will (1889).

The small anterior nuclei (Plate 6, fig. 41, *b*) have, by this time, arranged themselves in a single layer, which is closely in contact with the anterior surface of the mass of formative "mycetom." The former are still distinguishable due to their being relatively smaller than the "mycetoblasts," their more uniformly subglobular shape, the pseudopodlike structure in their surrounding cytoplasm, and also the fact that they are not embedded in the concentrated mass of "symbionts." I have unfortunately failed to trace to my satisfaction the subsequent history of these nuclei beyond this stage, but at no time do they ever show any sign of disintegration. Their persistently close relation to the mass of formative "mycetom" suggests that they may have something to do with the formation of the investing membrane of the definitive "mycetom."

Figure 41 also shows a single layer of cells (nuclei in syncytium?) (*gc*), appearing between the mass of formative "mycetom" and the germ cylinder on one side and the contiguous blastodermal wall on the other. The nuclei are subglobular or subellipsoidal, measuring about 7 to 8 micra in diameter, and possessing distinct nucleoli and less densely staining chromatin granules which, in sections, form a ring almost encircling the former. These nuclei are distinguishable from the "mycetoblasts," near some of which they are located, in that the former have more sharply defined nuclear membranes and, further, like the small anterior nuclei, they do not lie in the mass in which the "symbionts" are concentrated. As may be judged from the figure, there seems to be no question as to their being a distinct layer from the formative "mycetom." Principally on account of their relative position with respect to that part of the "germ cylinder" which in later developmental stages gives rise to the ventral plate of the germ band, I take these cells to be the "primitive germ cells," which are only becoming distinguishable at this stage.[25] On differentiation of the ventral plate and of the procephalic lobes, which apparently occurs almost simultaneously with the visible differentiation of the mass of primitive germ cells, the last occupies a mesodermal position.

The germ band is formed by a thickening of a certain area at the posterior portion of the blastodermal wall, with a corresponding process in the contiguous part of the "germ cylinder." The rest of the blastoderm and of the "germ cylinder" remain relatively thinner. The thickened posterior part of the blastoderm represents the earlier stages in the differentiation of the procephalic lobes (Plate 6, fig. 41, *pc*); the adjoining thickened piece of the "germ cylinder," the ventral plate (*vp*). The amnion (*am*) and the serosa (*se*) are represented by the thinner areas in the "germ cylinder" and in the blastodermal wall, respectively. In the case of the latter, there is also present at the anterior pole a conspicuously thicker layer (Plate 6, figs. 40, 41, *d*), which Will (1889) has called the "Scheitelplatte" and which he has attempted to homologize with the structure known under the same name in the Annelida. He has claimed that this thickened portion eventually migrates posteriorly and joins the ventral plate, thus giving rise to the procephalic lobes. On this basis, he has contended that the anlage of the head has an independent origin from the ventral plate. Wheeler (1893) has justly op-

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[25] In the foregoing pages, I have mentioned the fact that certain authors, like Balbiani (Henneguy, 1904, p. 405) and Buchner (1921) claimed to have observed earlier differentiation of the mass of primitive germ cells than I found in the case I have described. I have already noted my objection to Buchner's representation of the "germ-cells" in his fig. 58, *b*, wherein he has apparently confounded the mass of formative "mycetom" with the "germ cells." In his fig. 58, *c* and *d*, he has evidently taken for "germ cells" what I have referred to as small anterior nuclei, which I have traced from an earlier migration from the periplasm before differentiation of the blastoderm. They obviously cannot be "primitive germ cells."

The figure of Balbiani which I have just referred to is too diagrammatic to admit of any adequate discussion in regard to this question.

The position of the primitive germ cells on differentiation, as I have observed it in my material, agrees in a general way with the earlier descriptions of Metschnikow (1866) and of Will (1889). It should be noted that visible differentiation of the mass of primitive germ cells occurs in aphids much later than in coccids. As reported by Pierantoni (1914) and by Shinji (1919), the primitive germ cells in the latter family become distinguishable as fairly large cells at the posterior pole of the egg during early blastodermal stages.

posed this view, particularly in regard to the supposed homology between the aphid brain and the "Scheitelplatte" of annelids, for the former is segmented while the latter is not. This anterior thickening in the aphid blastoderm, so far as I am able to judge from its subsequent history in my own material, has apparently no such important morphological significance as Will has ascribed to it. It seems to be only a reserve mass which allows for a considerable stretching of the serosa as the embryo develops.

In fig. 41, *e* and *f*, both the ventral plate and the amnion are shown with the wall folded over entally at the anterior rim, so that the "germ cylinder" represents at this time a double invagination: (*a*) The primary, or original, anteriorly directed invagination from the rim of the blastopore, resulting in the formation of the main portion of the "germ cylinder;" and (*b*) a secondary, posteriorly directed invagination from the anterior rim of the first. The layer resulting from the latter process is unilaminar, and is closely applied upon the ental wall of the main cylinder. This secondarily invaginating structure is at first open at the posterior rim, but the gap is ultimately sealed over by cell proliferation. In this manner, the "germ cylinder" becomes covered at the anterior opening by a very loose, cellular sheet which is continuous with the walls of the former and which is capable of considerable extension. On completion of this new layer, the mass of formative "mycetom," as well as the rest of the inner cavity of the egg, becomes completely isolated from further direct communication with the follicular epithelium at the posterior pole.

The ventral plate continues to grow anteriorly, its caudal end,[26] in the meantime, pulling with it the adjoining loose cellular sheet which I have described above, as it increases in length. Eventually the latter becomes stretched and, in turn, drags along with it the amniotic part of the "germ cylinder" proper, the two together forming a continuous layer which becomes loosely applied upon the ventral surface of the ventral plate. It is doubtful if the cellular elements of the amnion and of its extension multiply appreciably; I infer this condition from the manner in which their cells quickly flatten out as a result of stretching. The same statement holds true with reference to the serosa.

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[26] It is now generally known that the embryo of the aphid, in common with those of other Homoptera, and like those of certain other groups of insects, develops with the head directed at first toward the posterior pole of the egg. Later, however, it orients itself so that the head ultimately points toward the anterior pole (Wheeler's "blastokinesis," 1893).

As the ventral plate elongates, the mass of formative "mycetom" becomes displaced from its former position. The latter now begins to occupy the large cavity formed by the side of the amnion which is away from the ventral plate, and its contiguous serosa. The "mycetoblasts," which are all apparently in a resting state, in the meantime move farther apart from each other, evidently as a result of expansion of the continually increasing mass of "symbionts."

The primitive germ cells accompany the dorsocaudal portion of the ventral plate, as the latter extends anteriorly. In the meantime, the former tend to collect into a subglobular or abruptly subellipsoidal mass.

I have made no careful observations on the early development of the procephalic lobes. It is evident, however, that they do not increase in size in proportion to the rapid elongation of the ventral plate.

When the egg reaches a length of about 120 micra and a cross-sectional diameter of 60 micra, or approximately twice its dimensions at the time the definitive blastomeres begin to become differentiated, the ventral plate has grown longer than the length of the egg and has curled over posteriorly at the anterior pole of the latter. A lateral view of the germ band at this stage (Plate 7, fig. 45) shows the **S**-shaped appearance, described by Will and by other earlier authors. The differentiation of the ectodermal and the lower layers of the germ band, which must have taken place previous to this stage, is unfortunately very inadequately represented in both my figures (Plate 7, fig. 45, and Plate 8, fig. 48).

The hook-shaped caudal half of the ventral plate occupies the anterior three-sevenths of the total length of the egg. The dorsal surface of the arched portion is closely applied against the serosa at the anterior pole. From the posterior termination of the curvature, the ventral plate is deflected entally at right angles to the longitudinal median axis of the egg, until its caudal end almost touches the contiguous amniotic layer.

A small piece of the amnion which is continuous with the caudal end of the ventral plate is applied anteriorly upon the latter. Distally, the former is connected with a still shorter portion of the amnion, which is deflected anteriorly at an angle of about 30° to 45° and is in turn joined by the main amniotic membrane. The latter piece runs anteroposteriorly between the anterior porrect half of the ventral plate on one side, and the latter's deflected caudal portion, the mass of primitive germ cells, and the formative "mycetom" on the other.

The primitive germ cells at this time form a subglobular mass (Plate 7, fig. 45; Plate 8, fig. 48, *gc;* Plate 3, fig. 19) which fits into the concavity in the deflected caudal piece of the ventral plate. The nuclei of the former are subglobular, measuring about 5 micra in diameter and each, with few exceptions, containing sparsely scattered, darkly staining chromatin granules and a distinct nucleolus. Some of the cells are apparently in early prophase.

Adjoining the foregoing region posteriorly is the formative "mycetom," which now occupies about one-third the total volume of the egg. This mass is bounded ectally and posteriorly by the serosa and entally by the amnion. The "mycetoblasts" measure about 6 micra in diameter and are characterized, as before, by the presence of sparsely distributed chromatin granules and of large and distinct nucleoli. This stage of embryonic development appears to cover the period in which the differentiation of the definitive cell territories of the "mycetom" takes place. The process apparently begins by the "mycetoblasts" first exhibiting signs of renewed mitotic activity (Plate 8, fig. 47), after which the mass of "symbionts" and the cytoplasmic network become constricted between the nuclei, thus marking out the ultimate cells.

Figure 45 also shows the persisting swollen portion of the egg follicle.

One other important feature in connection with this stage, as represented by figs. 45 and 48, is the fact that the invagination of the stomodæum takes place at about this time. The proctodæum does not begin to invaginate until later.

SUMMARY AND CONCLUSIONS

1. The periplasmic layer apparently foreshadows the future position and the extent of formation of the blastodermal wall.

2. The definitive cell territories of the blastoderm are formed by simple, simultaneous construction of the periplasm, between the nuclei which are embedded in the latter. A secondary "Keimhautblastem," which has been described in other groups of insects, has not been found in aphids.

3. Differentiation of the definitive cell territories in the blastoderm is accompanied by no appreciable increase in the size of the egg.

4. At first, the blastodermal wall occupies only the anterior and a fraction of the lateral sides in the periphery of the egg, leaving a small portion toward the posterior pole uncovered. By subsequent growth, however, the blastoderm eventually extends posteriorly until the entire length of the lateral sides of the egg is covered.

5. The blastoderm leaves an opening, or blastopore, at the posterior pole of the egg, at the region of the original gap left by the periplasm during the preceding cleavage stages.

6. Invagination of the "germ cylinder" is effected by proliferation of the cells at the blastopore. The "germ cylinder" at first is open, both anteriorly and posteriorly.

7. A longitudinal thickening of a part of the wall of the "germ cylinder" gives rise to the ventral plate of the germ band; a corresponding thickening of a contiguous portion in the blastodermal wall, to the procephalic lobes.

8. The thinner part of the "germ cylinder" represents the amnion, and a contiguous thinner portion in the blastodermal wall, the serosa. There is a thickening of the blastodermal wall, at the anterior pole, opposite the blastopore, but this apparently has no further morphological significance than an accumulation of reserve mass in the serosa, which allows for considerable expansion of that embryonic envelope during the subsequent developmental stages.

9. A secondary, posteriorly directed invagination occurs at the anterior rim of the "germ cylinder," resulting in the formation at this region of a loose cellular sheet covering the opening. This structure is capable of considerable extension, and ultimately becomes a continuation of the amniotic part of the "germ cylinder," thus adding very materially to the total expansive area of this particular embryonic envelope.

10. The ventral plate continues to elongate anteriorly until ultimately it exceeds the total length of the egg. Then its caudal half curls over posteriorly at the anterior pole, the ventral plate halfway doubling over itself around its ventral surface in this manner.

11. The procephalic lobes do not elongate in proportion to the growth of the ventral plate.

12. During these earlier stages, the cephalic region of the embryo is directed toward the posterior pole of the egg. Later,

however, the embryo turns around so that the head finally points toward the anterior pole, through a process which has been variously called blastokinesis, rotation, or orientation.

13. The "symbionts" which invade the egg cavity apparently become lodged within the meshes of the cytoplasmic network where they continue to multiply and, in the meantime, gradually appropriate the yolk.

14. After differentiation of the blastoderm, the inflow of the "symbionts" into the egg probably begins to diminish, as a result of the fact that a balance in concentration between the "symbiotic" mass in the egg cavity and that in the swollen portion of the follicular epithelium at the posterior pole is rapidly being approached.

15. The "mycetoblasts," which are in syncytium in the cytoplasmic network, together with the "symbionts," collect into a large, compact, subglobular mass at the posterior half of the blastocœle. The mass constitutes the formative "mycetom."

16. The formative "mycetom" is progressively pushed anteriorly in the blastocœle by the invaginating " germ cylinder," close to the anterior opening of which this organ is located.

17. As the ventral plate elongates, the loose cellular sheet at the distal end of the "germ cylinder," together with the amniotic part of the latter, is stretched anteriorly. As a result of the process, the formative "mycetom" becomes displaced in the cavity formed by the amnion and its contiguous serosa, at the posteroventral side of the germ band. While in this cavity, the "mycetoblasts" become widely dispersed, apparently owing to a rapid increase in mass of the "symbionts."

18. Definitive differentiation of the cellular elements of the "mycetom" occurs after the time when the ventral plate has curled over at the anterior pole of the egg, as summarized in paragraph 10 of this summary. Prior to cellular differentiation, the "mycetoblasts" exhibit renewed signs of mitotic activity.

19. The swollen portion of the follicular epithelium persists to this stage, when obviously there is no further need of reenforcement in the supply of "symbionts" from this source. This persistence is probably the result of a prolonged after effect of the original stimulus, exerted by the egg yolk during the earlier stages in the development of the egg.

20. The small anterior nuclei, which have originated from a secondary migration from the periplasm into the anterior portion of the egg cavity during the time that the definitive blastomeres are being formed, show no signs of degeneration during

any of the stages in which they are recognizable. Unfortunately, their actual ultimate disposal in the later embryonic stages has not been followed. Their very close association with the mass of formative "mycetom" suggests that they may have something to do with the formation of the investing membrane of that organ.

21. The mass of primitive germ cells is not in evidence until late in the blastodermal stages, almost simultaneously with the differentiation of the procephalic lobes and of the ventral plate. The mass of primitive germ cells at first appears in the form of a single, unilaminar layer, which is mesodermal in position, and which always follows the dorsocaudal portion of the ventral plate as the latter proceeds in its elongation. At a later stage, the primitive germ cells gather into a subglobular or abruptly subellipsoidal mass in the same relative location with respect to the ventral plate.

THE LATER EMBRYONIC STAGES

In the present account of the later stages in the development of the embryo, only the "mycetom" is taken up in detail. The other principal organs are merely mentioned in passing or characterized in general terms, with fragmentary notes used as supplement. A more thorough treatment of the various other parts of the embryo has of necessity been deferred, on account of the present incomplete state of my data relating to them.

Metameric segmentation first becomes manifest in the appearance in the germ band of wavy swellings, which extend to both the procephalic lobes and the ventral plate (Plate 7, fig. 44; Plate 8, fig. 49). In general, the process is similar to the condition which Graber (1888, 1890) has described in Diptera. Figure 49, of the present paper, which represents a sagittal section, sinistral aspect, of an egg of an unidentified species on *Lythrum*, shows a relatively more advanced stage, wherein the anlagen of appendages begin to appear. The "mycetom" remains in the same position that it occupied prior to metameric segmentation—in the cavity which lies posteroventrally with respect to the germ band, and which immediately adjoins the flexed caudal portion of the ventral plate.

The series represented by figs. 45, 48, 44, and 49 unfortunately has not been drawn from a single species. The figures show, in the order given here, the successive steps in the movement of the caudal end of the ventral plate. After assuming the curled-up position shown in fig. 45, the caudal piece proceeds to grow posteriorly, replacing the amnion by degrees, until the former finally occupies the original position of the latter close to the ental surface of the "mycetom." The anteroposteriorly descending portion of the ventral plate represents the abdominal region of the embryo. Its caudal end now lies only a little anteriorly to, and opposite the opening of, the stomodæum. Plate 9, fig. 51, and Plate 10, figs. 52 and 53, show the embryo after the abdominal region has assumed this position. Plate 1, figs. 3 and 4, represents corresponding surface views of embryos of about the same stage. The rudiments of the mouth parts and legs develop as ectodermal evaginations (Plate 9, fig. 51; Plate 10, figs. 52 and 53, *fe;* and fig. 54). The cavities thus formed are filled with mesodermal tissue (*ms*), which gives rise to muscles.

The mass of germ cells, which is constantly associated with the dorsocaudal end of the ventral plate, apparently begins to divide at this time into separate lots, each to be ultimately inclosed in a definitive germarium. The details of this partition have never been followed satisfactorily in aphids, and our knowledge in regard to the differentiation of the definitive ovarian parts in this group of insects still leaves much to be worked out. In certain favorable sections, I have noted a thick mesodermal layer (Plate 9, fig. 51, *ms*) covering portions of the surface of the mass of germ cells. By analogy with the Coccidæ, in which family the development of the various parts of the ovaries has been more satisfactorily studied (Pierantoni, 1914), this mesodermal layer probably gives rise to the parts of the ovary distally adjoining the vagina. According to Pierantoni's account, that mass of cells which I have interpreted in the present work as formative egg follicle also arises from the mesoderm, and it is not improbable that a similar process also occurs in so closely related a group as the aphids. The intimate association of the mesodermal layer referred to above with the "symbiotic organ" suggests the possibility of early infection during this time of the developing ovaries by the "symbionts."

The oögonia apparently arise directly from the primitive germ cells and are inclosed as such, by the definitive germarium, in much larger numbers than are needed for the production of ovarian eggs.

The proctodæum (Plate 9, fig. 51; Plate 10, figs. 52, 53, *pr*) apparently invaginates at this stage. The blind end of this invagination, as well as that of the stomodæum, which arises earlier, is adjoined by a thick layer of mesentoderm. The last presumably gives rise to the epithelial lining of the mesenteron, as described by Hirschler (1912).

The differentiation of the brain (*br*) from the procephalic lobes and of the subœsophageal and thoracic ganglia and ventral nerve chain from the ventral plate also becomes apparent at this time. In slightly older embryos (fig. 53, *ad*), adipose tissue is also in evidence along the dorsal part of the thoracic region.

A subglobular mass of cells (Plate 9, fig. 51; Plate 10, figs. 52, 53, *g*), which appears to be composed of a thick outer wall, inclosing an irregular cellular layer, appears at the opening of the stomodæum. Its position, as well as its shape, is very suggestive of the indusium, which Wheeler (1893) has described in *Xiphidium* and which has also been reported subsequently in certain Homoptera, as in *Siphanta* (Muir and Kershaw, 1912). In as much as, in the aphids, I have been able to trace neither the origin nor the subsequent history of this peculiar structure, I shall make no attempt definitely to establish its homology until I have had a chance to give it more thorough study.

The "mycetom," as in the preceding stage, occupies approximately one-third the total volume of the egg chamber, but it is now distinctly anterior in its position (Plate 10, figs. 52, 53, *my*). The developing embryo tends progressively to shift directly underneath this organ. The cellular elements of the "mycetom" ("mycetocytes") are clearly distinguishable. They number at this stage from about thirty to forty, and are yellowish green in fresh material, on account of the coloring matter of the "symbionts." The "mycetocytes" measure from 18 to 24 micra in diameter. The nuclei are subglobular, with distinct nucleoli, and a few dark-staining, widely scattered chromatin granules.

The last stage described above appears to be the one which immediately precedes orientation of the embryo. The egg of *Macrosiphum tanaceti* reaches a length of about 230 to 280 micra and a cross-sectional diameter of about 130 to 165 micra before the process takes place. My deductions from study of the aphid material I have on hand confirm in essential respects Brandt's (1869) description of orientation in this family. Pierantoni (1914) has also described a similar process in *Pseudococcus citri* Risso (Coccidæ). It takes place as follows: As the caudal end of the abdomen descends posteriorly to the position described above, in front of the stomodæum, the amnion becomes gradually released from its intimate connection with the "mycetom." The serosa is contiguous with the amnion. At the point of junction with the latter, an extension of the fold overarches the posterior opening of the "germ cylinder," so that the serosa appears to cover the entire periphery of the egg, except the procephalic lobes. As the amnion becomes detached from the ental surface of the "mycetom," the serosa contracts and draws the former with it, so that the two embryonic envelopes form a continuous, ectal amnioserosal membrane. Contraction proceeds, and the resulting anteriorly directed force causes an eversion of the embryo from its original, ventrally flexed posture. A surface view of an embryo of *Myzus persicæ* Sulzer at the conclusion of blastokinesis is shown in Plate 1, fig. 5. The mouth parts and the legs are still relatively short and undeveloped. The characteristic position of the abdomen, which is dorsally curved, as a result of rotation, is shown. Plate 11, fig. 56, represents a somewhat more advanced stage in *Macrosiphum tanaceti,* after the dorsal abdominal wall has been formed, replacing the amnioserosal membrane, which has disintegrated. It will be noted that, as a result of rotation of the embryo, the "mycetom" has moved from its anterior position, as shown in Plate 10, fig. 53, and settled into the cavity formed by the dorsal curvature of the abdomen. Up to this time, this organ persists as a single mass of cells, which apparently exert very little mutual pressure, a condition which I infer from their relatively more subglobular form. The twelve newly formed ovarioles, five of the germaria of which are shown in fig. 56, are arranged bilaterally in two groups, each embedded in either posterolateral side of the "mycetom." A median, sagittal section of the abdomen at this stage, showing the posterodorsally located opening of the proctodæum, is represented in Plate 12, fig. 57. The proctodæum in the figure includes only a small portion adjoining the opening.

The union of the stomodæum and the proctodæum into one single, continuous digestive tube takes place soon after orientation. I have not studied the details of the process. Hirschler (1912), however, after making a searching examination of the work of previous authors and correlating them with his own results, observes that the "Stomodäum und Proctodäum . . . . grösstenteils den Darmtractus aufbauen," while the entoderm (mesentoderm), a layer of which has been pointed out before as adjoining the blind ends of both the stomodæum and the proctodæum, "in den kleinen, unansehnlichen Mitteldarmanlagen repräsentiert, deren prospektive Bedeutung bei weitem geringer ist und die sich nur am Aufbaue der Darmschlinge beteiligen." Similar conclusions have been reached by Pierantoni (1914) in regard to the limited part played by the mesentoderm in the formation of the alimentary canal. Hirschler, therefore, contends that the anterior bulb-shaped enlargement of the digestive tube, which has often been taken for the mid-intestine (Plate 1, fig. 11; Plate 2, figs. 13, 14; Plate 7, fig. 46; Plate 13, fig. 61 *mi*), is really a modification of the foregut.

With the further development of the alimentary canal, the pressure which the foregut exerts posterodorsally and the hindgut anteroventrally on the mass of "mycetom" is apparently responsible for the bipartition of the latter into two longitudinal halves. A few dorsally located "mycetocytes" connect the two lobes of the "mycetom" subcaudally. This bridge, however, disappears later, during the nymphal stage, as the pressure exerted by the growing alimentary canal increases in that region. Plate 11, fig. 55, and Plate 13, fig. 62,[27] show two successive steps in the division of the "mycetom." Figure 55 is a cross section of the abdomen, passing through the bulb-shaped enlargement of the foregut. The embryo is practically of the same age as the one shown in fig. 56. The bipartition of the "mycetom" is only beginning to take place. Figure 62 is a section through the subcaudal portion of an older embryo, which is at about the stage shown in Plate 1, figs. 6, 7, and 8. The separation of the two lobes of the "mycetom" is nearly complete.

Figure 62 is one of the series of cross sections of an embryo which, in cephalocaudal order, are arranged as follows: Figs. 58, 59, 60, 61, and 62. The first two are sections of the cephalic region, showing the development of the various parts of the brain, and also of the mouth parts, including the "retort organs," at this stage. The "retort organs," which have been known for a long time (Metschnikow, 1866; Witlaczil, 1882; Zacharias, 1884, et al.), are present in two pairs, one in each side of the head. Plate 1, fig. 9, *ro*, also shows this structure.

Figures 60 and 61 are sections through the thoracic region. The first passes through the salivary glands and the subœsophageal ganglion; the second, through a portion of the bulb-shaped anterior enlargement of the foregut and one of the thoracic ganglia. The "mycetom" does not extend into the thoracic cavity.

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[27] The former represents *Macrosiphum tanaceti;* the latter, *M. rosæ.*

The arrangement of the "mycetom" in fig. 62 has already been described. A sagittal section of an embryo of the same stage, showing the dorsally located layer of "mycetocytes," is represented in Plate 7, fig. 46. A frontal section, through the nervous system, is shown in fig. 63. The cerebral lobes and other parts of the brain, and the subœsophageal and thoracic ganglia are very well developed at this stage. The abdominal cavity lateral to the nervous system is occupied mainly by adipose tissue; no "mycetom" is evident in this region.

A full-grown embryo of *Macrosiphum tanaceti,* which is about ready to be born, is shown in Plate 1, fig. 10, in surface view, and in fig. 11, a sagittal section a little to one side of the median line of the body. The embryo now measures about 840 micra in length; 264 micra in width; 240 micra in thickness, exclusive of legs; and 300 micra, with legs in natural position. The legs have grown considerably in length, so that the metathoracic pair curves around the caudal third of the abdomen to the other side. The haustellum has assumed its definitive tubular structure. The ungues and body hair are fully in evidence, and a general chitinization of the body wall is apparent in this, as well as in an earlier stage represented by fig. 9, so that they no longer readily take the stains which the younger embryos show beautifully.

The nerve chain, composed of the brain (*br*), the subœsophageal ganglion, and the thoracic and abdominal ganglia (Plate 1, fig. 11, and Plate 2, fig. 12, *ta*), is much longer in proportion to the body, as compared with that of the later nymphal and of the adult stages. The œsophagus (fig. 11, *oes*) extends from the pharynx dorsally and, from this vertical position, it bends posteriorly and joins the enlarged bulb-shaped portion of the digestive tube (*mi*). The point of junction of the œsophagus with this bulb-shaped enlargement is guarded by a posteriorly directed valve (Plate 2, figs. 13, 14, *vlv*). This enlargement, according to Hirschler, is not the mid-intestine, but is simply a modification of the foregut. The posteriorly adjoining part of the digestive tube is coiled into a single loop, and it is in a small portion of the latter that the mesenteron is represented.

The "mycetom" (fig. 11, *my*) is completely divided into two longitudinal halves, except at the subcaudal end, as before. The "mycetocytes" number from about sixty to seventy, indicating thus that the cells must have divided at least once since the first formation of the definitive cell territories of the "mycetom." They are subglobular or subpolygonal, as a result of mutual pressure, and measure about 45 micra in diameter. The "symbionts" are congested in the cytoplasmic region and, as in the preceding instars, obscure the cytoplasmic network, on account of their presence in enormous numbers. The nuclei measure about 10 micra, and present an irregularly subellipsoidal or subpolygonal aspect, with a densely staining, granular, chromatin network, and a large, distinct, subglobular nucleolus. The thin investing membrane is distinguishable here and there, on account of its narrowly subellipsoidal nuclei, among the "mycetocytes;" but I have been unable to determine whether there is a separate enveloping layer covering each "symbiotic" cell, or whether several cells are inclosed together by a common membrane. The investing membrane is apparently not continuous around the entire "mycetom."

One other interesting point in connection with the full-grown embryo is the fact that its enveloping follicular epithelium shows no signs of degeneration (Plate 1, fig. 11, *fe*). Plate 2, fig. 17, shows a portion of these epithelial cells (*fe*) which, although very widely stretched, apparently still retain perfect nuclear organization. The nuclei are elongately subellipsoidal, about 5 micra long, and filled with numerous, darkly staining chromatin granules. The cells are spindle-shaped, and measure about 70 micra in length and 1.5 micra in thickness. The persistence of the egg follicle to this late stage suggests that this tissue is probably the membranous sheet which envelopes the nymph at birth.

SUMMARY AND CONCLUSIONS

1. Metameric segmentation of the germ band begins to become manifest in the form of wavy swellings in both the ventral plate and the procephalic lobes.

2. After assuming the curled-up position at the anterior pole of the egg, the flexed portion of the ventral plate proceeds to grow posteriorly, and ultimately replaces the amnion at the ental wall of the "mycetom." The posteriorly flexed portion of the ventral plate at this time represents the abdominal region of the embryo.

3. As the amnion becomes dislodged, the serosa contracts, drawing the former ectally, so that the two embryonic envelopes form a continuous amnioserosal sheet. A progressive contraction of the combined envelopes apparently results in the rotation of the embryo, through anteriorly directed pull, causing eversion of the latter from its original, ventrally flexed position.

4. The rudiments of the appendages and of the internal organs are fully differentiated before orientation takes place.

5. The invagination of the proctodæum also occurs prior to blastokinesis. As stated previously, the stomodæum invaginates earlier, before metameric segmentation of the germ band.

6. The union, into one continuous digestive tube, of the fore-gut and the hind gut, by means of the mesenteric epithelium, which arises from the mesentoderm accompanying the blind ends of both the stomodæal and the proctodæal invaginations, occurs some time after blastokinesis.

7. Prior to orientation, there appears at the opening of the stomodæum a subglobular, cellular structure which is very suggestive of Wheeler's indusium. Its homology with the latter, however, cannot be established definitely at present, on account of the doubtful origin and subsequent history of this peculiar formation in aphids.

8. The persistently close association with the "mycetom" of the mesodermal layer which presumably gives rise to the various parts of the ovary distal to the vagina, apparently including the formative egg follicle, tends to bring about a condition wherein early infection of the last tissue by the "symbionts" may take place. In fact, on account of the constant intimate contact of the germ band with the formative "mycetom" as a result of which the lower layer of the ventral plate, from which the mesoderm in question develops, is bathed by the fluid loaded with "microörganisms," there is reason to believe that infection probably begins at an even earlier stage.

9. The oögonia apparently arise from the primitive germ cells, and are inclosed as such in the definitive germaria. They do not, as certain authors claim, originate from the egg follicle.

10. The apportionment of the oögonia into lots, each occupying one of the twelve germaria, apparently occurs prior to blastokinesis.

11. After orientation of the embryo, the ovarioles are embedded among the superficial cells of the "mycetom" at each lateral side.

12. As a result of the posteriorly directed growth of the flexed portion of the ventral plate, the "mycetom" is pushed from its original position at the anteroventral side of the embryo, near the posterior pole, to the anterior third of the egg. Accompanying blastokinesis, the "mycetom" is dislodged again from the latter position and shoved posteriorly into the dorsal curvature of the abdomen of the embryo.

13. The "mycetom," at first a single mass of "mycetocytes," becomes eventually divided into two lateral halves, apparently as a result of pressure exerted by the developing digestive tube, after orientation.

14. The "mycetocytes" appear to undergo cell division at least once during the embryonic stages, subsequent to definitive differentiation from the formative "mycetom." The resulting increase in number is from about thirty to forty to about sixty to seventy. The cells have grown in size also, from about 18 to 24 micra, immediately following differentiation, to about 45 micra in the oldest embryo.

15. The egg follicle apparently does not degenerate, but persists throughout the last embryonic stages. Such a condition indicates that this tissue is probably the origin of the thin, membranous envelope covering the nymph at birth.

THE "MYCETOM:" MORPHOLOGY AND DEVELOPMENTAL HISTORY IN THE POSTNATAL STAGES OF APHIDS

The "mycetom" of the newly born nymph, like that of the later prenatal stages, is a large mass of longitudinally bipartite organ, which extends from about the second to about the sixth or seventh abdominal segment. Each lobe measures, in lateral diameter, roughly one-fifth the greatest width of the abdomen, and occupies the cavity on either side of the alimentary canal. The organ lies nearer the dorsal than the ventral abdominal walls. The cellular investing membrane, which I have described before in connection with earlier stages, is still in evidence; this structure, also present in the "mycetom" of the adults (Plate 9, fig. 50, *im*), apparently persists during the entire life of the aphid.

As has been described in older embryos, a few "mycetocytes" connect the two lobes of the "mycetom" of the young nymph subcaudally above the rectum, and the organ at this time thus presents from the dorsal aspect a horseshoe-shaped form. This condition continues through about the second instar in *Macrosiphum tanaceti*. During the third instar, the connecting bridge disappears, presumably through increased pressure accompanying the further increase in diameter of the digestive tube in this region.

The developing ovarioles, as before, are embedded in the ectolateral sides of the lobes of the "mycetom," among the more superficial "mycetocytes." With the development of the eggs, which at the same time continually increase in number by additional extrusion from the germaria, the abdominal cavity soon becomes overcrowded so that the "mycetom" is compressed. The result is that, at about the fourth instar, the latter organ is reduced to isolated groups of two, three, or more cells, lodged in the interstices formed by adjacent ovarioles. Later, many of the "mycetocytes" are forced out, partly to the anterior and partly to the subcaudal region of the abdominal cavity, contiguous to the anterior and the posterior ends of the groups of ovarioles, respectively. Ectally, the "symbiotic" as well as the other internal organs in the abdomen are bounded by a thick layer of adipose tissue, which lines the inner wall of the body cavity.

With the exception of certain differences which I am pointing out in the footnote, I have confirmed some of the important details in Witlaczil's (1882) earlier description of the "mycetom." This author bases his account on "*Aphis pelargonii, A.* (*Drepanosiphum*) *platanoides, A. sambuci, Chaitophorus populi, Pemphigus bursarius,*" and several other species of aphids. He reports that this organ—

> liegt seitlich im Abdomen in Form zweier Stränge, die zwischen den dorso-ventral verlaufenden respiratorischen Muskeln der Abdominalsegmente sich hinziehen. Im ersten Abdominalsegmente beginnend, gehen diese Stränge zwischen den erwähnten Muskeln sich immer verengernd durch das zweite, dritte, vierte und fünfte Segment, und vereinigen sich oberhalb des Enddarmes ungefähr im sechsten Segmente, in eine Spitze nach hinten auslaufend, die * * * mit dem Enddarme zusammenhängt.[28]

Witlaczil has also reported the peculiar arrangement in certain species, like *Callipterus tiliæ* Linnæus, in which the two lobes of the "mycetom" are joined by the connecting bridge anteriorly instead of subcaudally. I have never come across this interesting condition in any of my material.

There is no evident direct connection between the "mycetom" and the contiguous organs, in the form of tubes, ducts, or other similar accessories, except the tracheoles of the respiratory system. The tracheation of the "mycetom" can be studied in favorable sections. As shown in Plate 9, fig. 50, the points where the tracheoles join this organ are apparently without process, the termination of the former being characterized by a simple opening. These tracheoles are relatively large, measuring about 7 micra in cross-sectional diameter. The size is probably correlated with very active metabolic processes which go on within the "mycetocytes," acompanying the presence of the "symbiotic organisms." Large conducting tubes are, therefore, presumably required for securing an adequate supply of oxygen for this organ and, as Pierantoni (1910a) has previously suggested, for elimination of waste gaseous products which result from the chemical action brought about by the "symbionts." I have not been able to determine whether each individual "mycetocyte" is supplied with a tracheole, or two or more of these cells have a common source of air supply. Of the total of nine pairs of spiracles[29] present in *Macrosiphum,* only seven abdominal pairs apparently have direct connection with the respiratory equipment of the "mycetom."

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[28] As will be noted by comparing Witlaczil's account with mine, I disagree with him in that, according to my observations on *Macrosiphum tanaceti*, the "mycetom" extends from the second to the sixth or seventh abdominal segment, instead of from the first to the sixth. Further, it is evident that Witlaczil has based his description entirely on the younger nymphs, as may be judged from his failure to notice the disappearance of the subcaudal connecting bridge of the two lobes of the "mycetom" at about the second instar. There is, likewise, no mention in his paper of the ultimate dispersal of the organ into isolated groups of cells, as a result of compression by the developing eggs.

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[29] Witlaczil (1882) contends that in the species he worked with the first pair really belongs to the mesothorax, and that the prothorax is without spiracles. He says: "Das erste Stigma liegt seitlich auf der Grenze von Pro- und Mesothorax und ist wahrscheinlich * * * nur nach Verlust des Stigma des Prothorax nach vorn gerückt, gehört aber dem Mesothorax an. Die folgenden Stigmen liegen auch seitlich von Vorder- und Hinterrand des betreffenden Segments ziemlich gleich weit entfernt und zwar das zweite im Metathorax und die folgenden in den ersten sieben Abdominalsegmenten. Die drei letzten Segmente sind ohne Stigmen."

My own findings on *Macrosiphum tanaceti* appear to agree with Witlaczil's. In *Macrosiphum* the spiracles are arranged parallel to the lateral margins of the dorsal sclerites and, as Bonnet (1779) has pointed out previously in other species of aphids, are in line with the bases of the cornicles. The area which borders the rim of each stigmatal opening is piceous, concolorous with the legs, and the location is marked by an abrupt depression in the body wall, so that its presence can hardly escape observation. The spiracle (Plate 2, fig. 15) is characterized by the elevation and partial arching of one-half of the tube over the rim of the other half. The latter portion is marked by a contiguous, superficial groove, producing the rim into a moderately thick, ectally directed ridge, which is subconfluent entally with the adjoining wall of the trachea and almost touches the wall of the other half. The groove and the ental portion of the opposite wall bear long hairs, which are matted together and which presumably protect the tracheal opening by keeping off dust particles. The average diameter of the stigmata in adult *Macrosiphum* is 2 micra.

The component cells of the "mycetom" in the newly born nymph are subglobular, as in the latest prenatal stages and, like those of the latter, show no evidence of very much mutual pressure. They measure from about 42 to 45 micra in diameter, with an average of 44 micra, or almost equal to the measurements of these cells shortly before birth of the aphid. The nucleus is irregularly subglobular, and measures from 9 to 12 micra in diameter. The nucleolus is large and stains deeply in Ehrlich's acid hæmatoxylin. The chromatin network is densely arranged, giving the karyolymph a dark, granular appearance. The nuclear region is never invaded by the "symbionts." As in the later embryonic stages, the "symbionts" have so crowded together in the cytoplasmic mass that the latter has been reduced to an extremely delicate, almost imperceptible, interwoven strand, sustaining the "organisms." On casual examination, one would gain the impression that the "symbionts" have so completely occupied the space between the nuclear membrane and the periphery of the "mycetocyte" that even the intervening cytoplasmic strands have disappeared.

In the adult, the apparently normal "mycetocytes" (Plate 6, fig. 43) measure from about 72 to 108 micra, with an average of about 92 micra. These figures represent an increase of about two or two and one-half times the size of "mycetocytes" of the newly born nymphs and of the older embryos. The persistent closely packed condition of the "symbionts," even in the "mycetocytes" of the adult, indicate that the "organisms" have multiplied correspondingly. The increase in size of the "mycetocyte," however, is not due to increase in number of these cytoplasmic inclusions alone, for the cell itself must have grown also. I infer the latter condition from the fact that the nucleus of the "mycetocyte" has correspondingly increased in diameter from 9 to 12 micra in the later embryonic and earlier nymphal stages, to about 18 to 20 micra in the adult.

Except in size the nuclei of the adult "mycetocytes" are identical in structural characters to those of earlier instars. As the aphid reaches the adult stage, some of those nuclei become so irregular as to appear almost amœboid, while others assume a narrowly elongate form. This condition is probably brought about by increasing mutual pressure of the "mycetocytes" as they grow in size, or to their being more tightly compressed by the developing embryos.

My criterion in judging normal "mycetocytes" is principally the green color of the cells, which is due to granular, probably chlorophylloid, inclusions of the "symbionts." These green cells are more numerous than the others, which are described below, and the "microörganisms" within them are more compactly arranged.

The other kind of "mycetocyte" measures from about 131 to 162 micra in diameter. It is yellowish or greenish brown, and readily breaks enabling the contents to ooze out rapidly when the fresh aphid is dissected in Ringer's solution. These cells are less numerous than the green "mycetocytes" described above and they are interspersed among the latter. I interpret these brown "mycetocytes" as cells which degenerate after having completed their term of service. The yellowish brown color is apparently due to the loss of green coloring matter by the "symbionts," presumably as a result of untoward conditions in the cells causing death of the former.

I am inclined to accept Flögel's (1905) view that the "mycetocytes" do not undergo further cell division after birth of the nymph, but that they merely increase in size. Neither in the adults nor in any of the nymphal instars have I found indications either of karyokinesis or of amitosis, although I have looked particularly for them. Contrary to the present observations are the findings of Šulc (1910), who claims to have noticed mitosis among the "mycetocytes" of adult *Aphis amenticola* (?) Kaltenbach. He reports that "zur Zeit, wo die meisten Eier reifen oder sich im Leibe des Tieres in Furchung befinden (vivipare Arten) auch im 'Pseudovitellus' (meine Mycetocyte) reiche Furchungsfiguren zu finden sind." I have not been so fortunate in any of the species I worked with, although in some of the adults I have noted that many of the nuclei of the "mycetocytes" are very much distorted, so that in some cases their form resembles superficially certain mitotic phases, particularly the late anaphase and the telophase.

The "mycetocytes" present in an individual aphid number about sixty to seventy in the nymphal instars, as in the older embryos. Soon after reaching the adult stage, the cells begin to degenerate, one by one until, finally, the mother, exhausted as a result of her rôle of producer and about to die, has only a few "mycetocytes" remaining within her body.

The "mycetom" is also present in the amphigonous forms, both in the male and in the female.

SUMMARY AND CONCLUSIONS

1. The "mycetom" of the newly born nymph is a longitudinally bipartite organ, extending from about the second to about

the sixth or seventh abdominal segment. Each lobe occupies the cavity on either side of the alimentary canal.

2. The bridge of "mycetocytes" which connects the subcaudal portion of the two lobes of the "mycetom" persists through about the second instar. It disappears during the third instar, presumably as a result of increased pressure exerted by the growing digestive tube at this region.

3. As the aphid passes to the fourth instar, the "mycetom" is reduced to isolated groups of two, three, or more "mycetocytes," located anteriorly and posteriorly with respect to the ovarioles and in the interstices formed by the adjacent portions of the latter. This condition apparently results from compression accompanying the rapid increase in number and continued development of the eggs, which become progressively overcrowded in the abdominal cavity.

4. The investing membrane of the "mycetom" persists throughout the life of the aphid.

5. The "mycetom" is supplied with relatively large tracheoles, measuring about 7 micra in diameter. The increased metabolic activity accompanying the presence of the "symbionts" in this organ presumably requires these large-sized conducting tubes, in order to insure a plentiful supply of oxygen, as well as to provide for elimination of poisonous gases.

6. There is no increase in the size of "mycetocytes" accompanying birth of the aphid. The "mycetocytes" of the newly born nymphs measure from about 42 to 45 micra, with an average of about 44 micra.

7. After birth of the aphid, the "mycetocytes" apparently do not undergo further cell division. They increase in size only, due partly to increase in the number of the "symbiotic" cytoplasmic inclusions, and partly to growth of the cell itself.

8. The total number of "symbiotic" cells present in each individual aphid during the nymphal instars ranges, within fairly uniform limits, from about sixty to about seventy, as in full-grown embryos.

9. By the time the adult stage is reached the cells measure from about 72 to about 108 micra, the average being 92 micra. These figures represent an increase of about two to two and one-half times the dimensions of the "mycetocytes" of the newly born nymphs and of the older embryos.

10. After reaching the adult stage, the "mycetocytes" degenerate, one by one, until toward the close of the life of the

aphid only very few of these cells are left in her abdominal cavity.

11. The "mycetom" is present also in the amphigonous forms, both in the male and in the female.

GENERAL SUMMARY

The follicular epithelium, which apparently becomes infected by the "symbionts" during the early stages at about the time of or before differentiation of its formative cells, harbors these "microörganisms," evidently in a dormant condition. On contact with the egg yolk, during the earlier cleavage stages of the egg, the dormant "symbionts" become suddenly stimulated. The stimulus brings about the rapid multiplication of the latter, which causes considerable swelling in the portion of the follicular epithelium adjoining the posterior pole. As a result of this activity, the "symbionts" break through the thin epithelial cells and invade the posterior portion of the egg cavity through the posterior opening in the periplasm. They occupy the meshes of the cytoplasmic network and appropriate the yolk mass which is inclosed there.

The "vitellophags," which I have called "mycetoblasts" in the present work on account of their subsequent, apparently more important rôle, show marked attraction to the "symbionts" and tend to aggregate in the posterior half of the egg cavity. The attraction of the "mycetoblasts" to the inflowing granular mass, which process is very suggestive of the behavior of leucocytes in the presence of foreign protein (phagocytosis) as well as the stimulation of these granules in the follicular epithelium on contact with the egg yolk, tends to add weight to the contention that the supposed "symbionts" are really extraneous microörganisms, and not by-products of the insect's own metabolism.

The "mycetoblasts" form a subglobular mass, together with the cytoplasmic network, in which they are in syncytium, and the inclosed "symbionts." In this manner the anlage of the "mycetom" is established. Definitive cellular differentiation of the formative "mycetom" takes place after an active mitotic division of the "mycetoblasts," shortly before metameric segmentation of the germ band. At first existing as a single mass of "mycetocytes," this organ becomes divided into two lateral halves, apparently as a result of pressure exerted by the developing digestive tube. At about the fourth instar, the "mycetom" becomes reduced to isolated groups of two, three, or more "mycetocytes," as a result of compression by the overcrowded and continually growing embryos. The organ is supplied with large tracheoles.

After differentiation of the definitive "mycetocytes," these cells divide at least once during the embryonic stages of the aphid, increasing in number from about thirty to forty to about sixty to seventy. After birth of the aphid, the "mycetocytes" apparently cease to undergo cell division. They merely increase in size, from about 42 to about 45 micra in the first instar to about 72 to 108 micra in the adult. The increase in size is evidently due, not only to the increase in number of "symbionts" inclosed in the cytoplasm, but also to growth of the cell itself. Upon reaching the adult stage, the "mycetocytes" begin to degenerate, one by one, until at about the close of the life of the aphid only very few are left in her abdominal cavity.

The "symbionts" never invade the nucleus of the "mycetocyte." The characteristic green color of the "mycetom" is apparently due to the green granular inclusions of the "microorganisms."

The "mycetom" is present in every individual aphid, whether amphigonous, male or female, or parthenogenetic. In parthenogenetic forms, the direct association of the host with the "symbionts" begins to take place during very early cleavage stages of the egg.

The germarium of the parthenogenetic aphid, on definitive differentiation, contains a number of cells, which are apparently all secondary, or ultimate oögonia. The latter apparently arise directly from the primitive germ cells. These cellular inclusions are far in excess of the total number of those which develop as ovarian eggs. The supernumerary oögonia apparently represent a reserve supply which insures the production of the maximum possible number of young. While in the germarium, these cellular inclusions probably have a secretory function, contributing to the nourishment of the young ovarian egg. The oögonia begin to develop into oöcytes at the posterior part of the germarium, and they are extruded in succession from this region into the vitellarium.

Extrusion of oöcytes into the vitellarium begins at about one day and fourteen hours to about three days and one hour, the average being about two days and seven hours, prior to birth of the mother. Two ovarian eggs are extruded into each vitellarium during the prenatal stages of the mother. Maturation and subsequent cleavage of the egg take place soon after extrusion from the germarium. The time required for the development of the full-grown embryo, beginning with the extrusion of the oöcyte, covers a period of from about twelve days to about thirteen days and one hour, the average being about twelve days and thirteen hours. The entire embryonic life is passed in utero; and, in the case of about 75 per cent of the total number of young produced by each individual female, more or less advanced developmental stages are reached during the immature life of the mother. In as much as the extrusion and subsequent intrauterine development of the parthenogenetic aphid egg correspond to the deposition and subsequent incubation of the zygogenetic egg, ovulation and the subsequent development which take place during the preadult stages of the viviparous aphid represent a true case of pædogenesis, although the resulting young is born after the mother has reached the adult stage. A much larger percentage of parthenogenetic aphid young, therefore, is produced pædogenetically than otherwise. A redefinition of von Baer's original term is proposed in the present paper, wherein this method of reproduction, peculiar to aphids, is included under the subdivision of unisexual entopædogenesis.

The development of the parthenogenetic egg of aphids is described. The centrolecithal egg, which is familiar to all workers on arthropod embryology, differs in the case of the aphids from those of related groups in that the periplasm and, subsequently, the blastoderm leave an opening at the posterior pole. A direct communication between the follicular epithelium adjoining this region and the egg cavity is thereby established. This arrangement is apparently a special adaptation, accompanying "symbiosis," by which the "microörganisms" are enabled readily to enter the egg cavity.

Invagination occurs at the posterior opening of the blastoderm (blastopore). A portion of the "germ cylinder" thus formed thickens longitudinally and gives rise to the ventral plate; a corresponding thickening in the contiguous parietal area in the blastoderm gives rise to the procephalic lobes. The amnion and the serosa arise from the thinner parts of the "germ cylinder" and of the blastoderm, respectively. The former becomes considerably augmented by an extensible cellular sheet which arises from a secondary, posteriorly directed invagination at the anterior end of the "germ cylinder," the overgrowing layer ultimately closing the opening at that region. With the subsequent growth of the ventral plate, this sheet is stretched by being pulled anteriorly by the former and finally becomes continuous posteriorly with the amnion.

The embryo at first grows with the head directed posteriorly. Blastokinesis occurs when the rudiments of the appendages and of the internal organs are well differentiated. The junction of the stomodæum with the proctodæum does not take place until after orientation of the embryo.

The mass of primitive germ cells becomes easily distinguishable when the "germ cylinder" is well formed, perhaps simultaneously with the early thickening of the ventral plate and the procephalic lobes. The mass of germ cells is constantly associated with the posterodorsal end of the ventral plate.

The formative egg follicle is represented by a large mass of cells adjoining the posterior portion of the terminal chamber, the former being evident from the time of the early differentiation of the latter. The egg follicle is formed by anterior circumcrescence of the formative egg follicle around the ovarian egg, until the latter is finally inclosed. At the completion of the process, the layer of epithelial cells covering the anterior pole of the egg proliferates into a thick, multilaminar mass. The latter structure takes the place of the original matrix of the egg follicle, and the process of formation of the eipithelum around the new ovarian egg is repeated, as described above.

The egg follicle apparently persists, without degenerating, through the latest embryonic stages. It probably constitutes the thin, membranous envelope which covers the young at parturition. This usually ruptures before extrusion of the young through the vaginal slit is completed.

The parthenogenetic *Macrosiphum* has twelve ovarioles, arranged bilaterally in two equinumeral groups. They are attached anteriorly, by means of terminal filaments, to the dorsal diaphragm, at about the junction of the metathoracic and the first abdominal segments. Posteriorly, each of the groups of ovarioles joins one of the two short oviducts. The vagina is characterized by a relatively much thinner wall than that of the amphigonous aphid, and by the absence of spermatheca and of colleterial glands.

A review of the literature on reproduction and parthenogenetic embryology, and also on "symbiosis" and "symbiotic organs" in aphids is given in the present paper.

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ILLUSTRATIONS

[All figures represent parthenogenetic material, unless otherwise specified. **Magnifications** indicated refer to size of original figures.]

ABBREVIATIONS

ad, adipose tissue.
am, amnion.
an, anus.
ap, anal plate.
at, antennæ.
b, small anterior nuclei.
bl, blastoderm.
br, brain.
c, vestige of matrix of egg follicle.
caud, abdominal cauda.
ce, cerebral lobes.
crn, cornicle.
cyl, "germ cylinder."
d, thickened anterior portion of blastoderm and, later, of serosa.
e, portion of secondary invagination of "germ cylinder" over amnion.
em, entoderm.
eo, embryo.
f, portion of secondary invagination of "germ cylinder" over ventral plate.
fb, formative blastoderm.
fe, egg follicle.
fil, terminal filament.
fm, formative mycetom.
g, indusium (?).
gc, germ cells.
gm, germarium, or terminal chamber.
gon, rudimentary gonapophysis.
gp, genital plate.
hg, hind gut.
hyp, hypodermis.
im, investing membrane of "mycetom."
int, chitinous intima.
lv, labium.
mb, "mycetoblast" ("vitellophag").
md, mandible.
mem, basement membrane.
mi, "mid-intestine" (bulb-shaped thickening of foregut).
mp, maxillary palpus.
ms, mesentoderm.
mu, muscle.
mx, maxilla.
my, "mycetom."
oc, oöcyte.
oe, œnocyte.
oes, œsophagus.
og, oögonium.
op, vaginal slit.
or, ovary.
ov, ovarian egg.
ovd, oviduct.
pc, procephalic lobes.
pe, anlage of leg.
pm, periplasm.
pr, proctodæum.
se, serosa.
sg, subœsophageal ganglion.
sm, stomodæum.
sv, salivary gland.
ta, thoracic ganglia.
tr, trachea.
vag, vagina.
vit, vitellarium.
vlv, anterior valve of "mid-gut."
vp, ventral plate.

PLATE 1

FIG. 1. *Macrosiphum tanaceti;* apterous adult, caudal portion of abdomen, lateral view. × 175.

2. *Drepanosiphum platanoides;* nymph, sagittal section through right side, showing position of "mycetom" in abdominal cavity, 7 micra; Gilson's fixative; Ehrich's hæmatoxylin. × 175.

FIGS. 3–9. *Myzus persicæ;* successive stages of embryos. Figs. 3 and 4, latest stages prior to blastokinesis; fig. 5, immediately after blastokinesis; figs. 6, 7, 8, and 9, older embryos, showing subsequent development of appendages. Bouin's fixative; Gage's Säurefuchsin. × 365.

FIG. 10. *Macrosiphum tanaceti;* full-grown embryo, about ready to be born, ventral view, fresh; Ringer's solution. × 175.

11. *Macrosiphum tanaceti;* same age as fig. 10, sagittal section, 5 micra; Webster and Phillips's fixative; Ehrlich. × 365.

PLATE 2

FIG. 12. *Macrosiphum rosæ;* central nervous system of full-grown embryo, sagittal section, 7 micra; Gilson; Ehrlich. × 365.

13. *Macrosiphum tanaceti;* longitudinal section through "mid-intestine" of embryo, showing development of anterior valve, 7 micra; Gilson; Ehrlich. × 720.

14. *Macrosiphum rosæ;* longitudinal section through anterior portion of "mid-intestine" of adult, 7 micra; Gilson; Ehrlich. × 720.

15. *Macrosiphum tanaceti;* longitudinal section through spiracle and contiguous portion of trachea, 7 micra; Kleinenberg's fixative; Ehrlich. × 1,400.

16. *Macrosiphum rosæ;* adult; sagittal section through caudal portion of abdomen, showing vagina and portion of one of the ovaries, 7 micra; Gilson; Ehrlich. × 700.

17. *Macrosiphum tanaceti;* longitudinal section through portion of one of the oviducts and of a contiguous vitellarium, showing persisting egg follicle around a full-grown embryo, 6 micra; Kleinenberg; Ehrlich. × 1,400.

18. *Macrosiphum tanaceti;* left two-thirds of cross section of vagina, 6 micra; Kleinenberg; Ehrlich. × 1,400.

PLATE 3

FIG. 19. *Macrosiphum tanaceti;* mass of germ cells in embryo before metameric segmentation of latter, 7 micra; Gilson; Ehrlich. × 2,800.

20. *Macrosiphum rosæ;* ovariole of very young embryo; cellular inclusions of germarium all oögonia; longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

21. *Macrosiphum rosæ;* ovariole of older embryo, showing passing of ultimate oögonia into oöcytes, preparatory to extrusion of latter, longitudinal section, Gilson; Ehrlich. × 1,400.

FIG. 22. *Macrosiphum tanaceti;* anterior portion of ovariole of nymph, first instar, showing extrusion of "ovarian egg" and formation of egg follicle, longitudinal section, 5 micra; Gilson; Ehrlich. × 1,400.

23. *Macrosiphum tanaceti;* anterior portion of ovariole of nymph, second instar, showing completion of egg follicle around "ovarian egg," longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

24. *Macrosiphum tanaceti;* oögonium, 7 micra; Gilson; Ehrlich, × 1,400.

25. *Macrosiphum tanaceti;* full-grown "ovarian egg," prior to extrusion of polar body, longitudinal section, 6 micra; Gilson; Heidenhain-eosin. × 1,400.

26. *Macrosiphum tanaceti;* egg, extrusion of polar body, longitudinal section, 6 micra; Gilson; Heidenhain-eosin. × 1,400.

27. *Macrosiphum tanaceti;* egg, after extrusion of polar body; one-nucleus stage, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

PLATE 4

FIGS. 28–32. *Macrosiphum tanaceti;* eggs, cleavage stages, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

33–35. *Macrosiphum tanaceti;* eggs, preliminary steps in blastoderm formation, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

PLATE 5

FIG. 36. *Macrosiphum tanaceti;* egg, late preblastodermal stage, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

37. *Macrosiphum tanaceti;* egg, differentiation of blastomeres, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

38. *Macrosiphum tanaceti;* egg, early blastoderm stage, longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

39. *Macrosiphum tanaceti;* egg, blastoderm stage, immediately before invagination of "germ cylinder," longitudinal section, 7 micra; Gilson; Ehrlich. × 1,400.

PLATE 6

FIG. 40. *Macrosiphum tanaceti;* egg, blastoderm stage; invagination of "germ cylinder," longitudinal section, 7 micra; Gilson; Delafield. × 1,400.

41. *Macrosiphum tanaceti;* egg, differentiation of ventral plate and procephalic lobes, segregation of germ cells, longitudinal section, 5 micra; Gilson; Ehrlich. × 1,400.

42. *Macrosiphum tanaceti;* section through "mycetocyte" of full-grown embryo, 5 micra; Webster and Phillips; Ehrlich. × 1,400.

43. *Macrosiphum tanaceti;* section through "mycetocyte" of adult, 5 micra; Webster and Phillips; Ehrlich. × 1,400.

PLATE 7

FIG. 44. *Macrosiphum tanaceti;* egg, beginning of metameric segmentation of germ band, sagittal section, 7 micra; Kleinenberg; Heidenhain-eosin. × 720.

45. *Macrosiphum tanaceti;* egg, prior to metameric segmentation of germ band, before cellular differentiation of "mycetocytes." Note the persisting swollen part of egg follicle adjoining the posterior pole. Sagittal section, 7 micra; Gilson; Ehrlich. × 1,400.

46. *Macrosiphum rosæ;* embryo, nearly full grown, sagittal section, 7 micra; Gilson; Ehrlich. × 1,400.

PLATE 8

FIG. 47. *Macrosiphum tanaceti;* formative "mycetom," with "mycetoblasts" in mitosis, preparatory to differentiation of "mycetocytes," 7 micra; Gilson; Ehrlich. × 1,400.

48. *Macrosiphum tanaceti;* egg, slightly older than fig. 45, shortly before metameric segmentation of germ band, definitive "mycetocytes" differentiated, sagittal section, 5 micra; Gilson; Ehrlich. × 1,400.

49. Unidentified species on *Lythrum;* egg, metameric segmentation of germ band, sagittal section, 7 micra; Gilson; Heidenhain-eosin. × 720.

PLATE 9

FIG. 50. *Macrosiphum tanaceti;* portion of "mycetom," showing tracheation and investing membrane, 7 micra; Kleinenberg; Ehrlich. × 1,400.

51. *Macrosiphum tanaceti;* embryo, shortly before blastokinesis, sagittal section, 5 micra; Kleinenberg; Ehrlich. × 1,400.

PLATE 10

FIG. 52. Unidentified species on *Lythrum;* embryo, showing development of appendages and of internal organs, prior to blastokinesis, sagittal section, 7 micra; Gilson; Heidenhain-eosin. × 1,400.

53. *Macrosiphum tanaceti;* embryo, slightly older than stage corresponding to fig. 52, prior to blastokinesis, sagittal section, 6 micra; Kleinenberg; Heidenhain-eosin. × 720.

54. *Macrosiphum tanaceti;* details of one of the developing thoracic legs of fig. 53. × 1,400.

PLATE 11

FIG. 55. *Macrosiphum tanaceti;* young embryo, about the same age as fig. 56, cross section, through anterior portion of abdomen, showing preliminary steps in bipartition of "mycetom," 5 micra; Gilson; Ehrlich. × 720.

56. *Macrosiphum tanaceti;* embryo, shortly after blastokinesis, sagittal section, 5 micra; Webster and Phillips; Ehrlich. × 720.

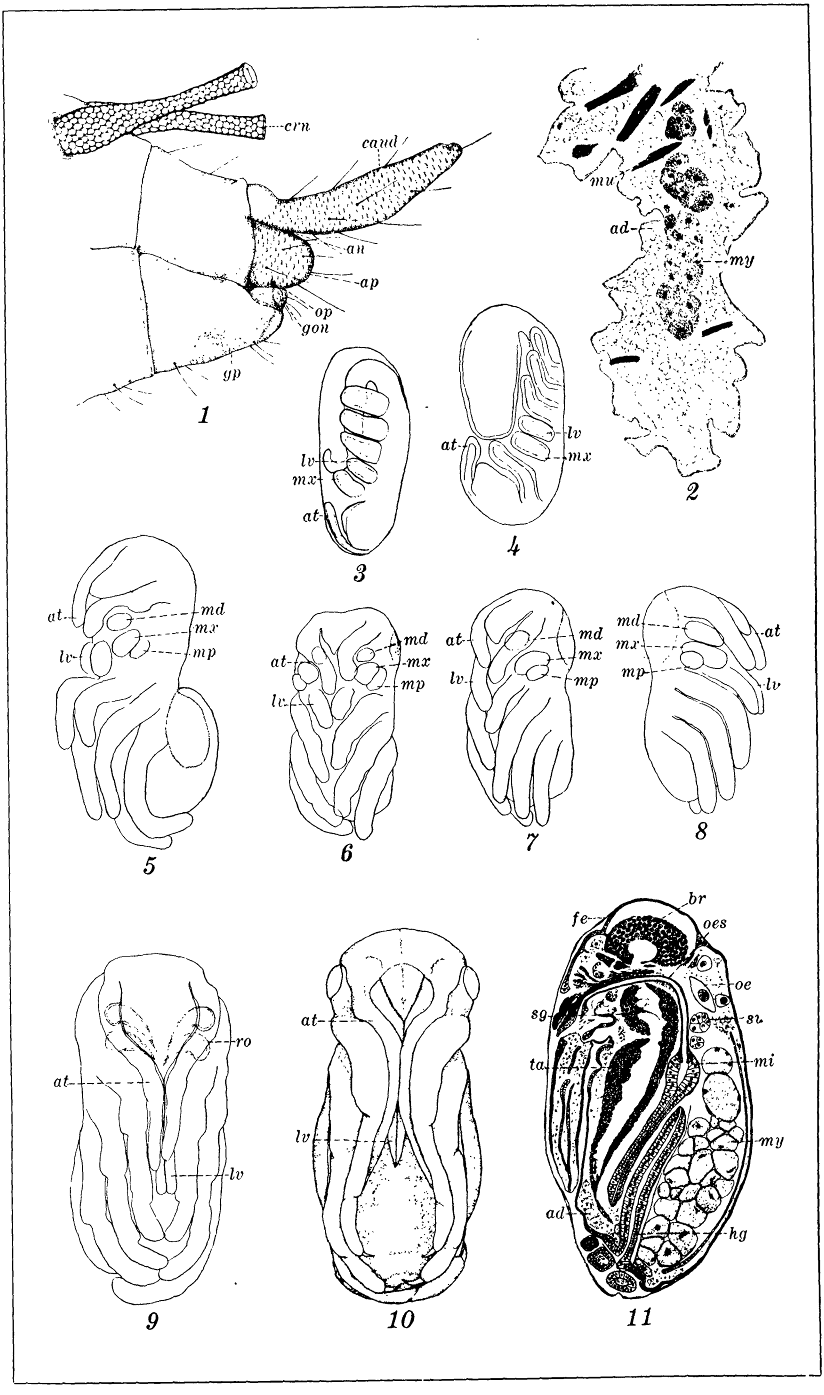
PLATE 12

FIG. 57. *Macrosiphum tanaceti;* embryo, the same age as fig. 56, sagittal section through caudal portion of abdomen, showing early relation of proctodæum with "mycetom," 5 micra; Webster and Phillips; Ehrlich. × 1,400.

PLATE 13

FIGS. 58–62. *Macrosiphum rosæ;* embryo, nearly full grown, cephalo-caudal series of cross sections; figs. 58 and 59, through head; figs. 60 and 61, through thorax; fig. 62, through sub-caudal portion of abdomen; 7 micra; Gilson; Ehrlich. × 365.

FIG. 63. *Macrosiphum rosæ;* embryo, the same age as the preceding; frontal section through central nervous system, 7 micra; Gilson; Ehrlich. × 365.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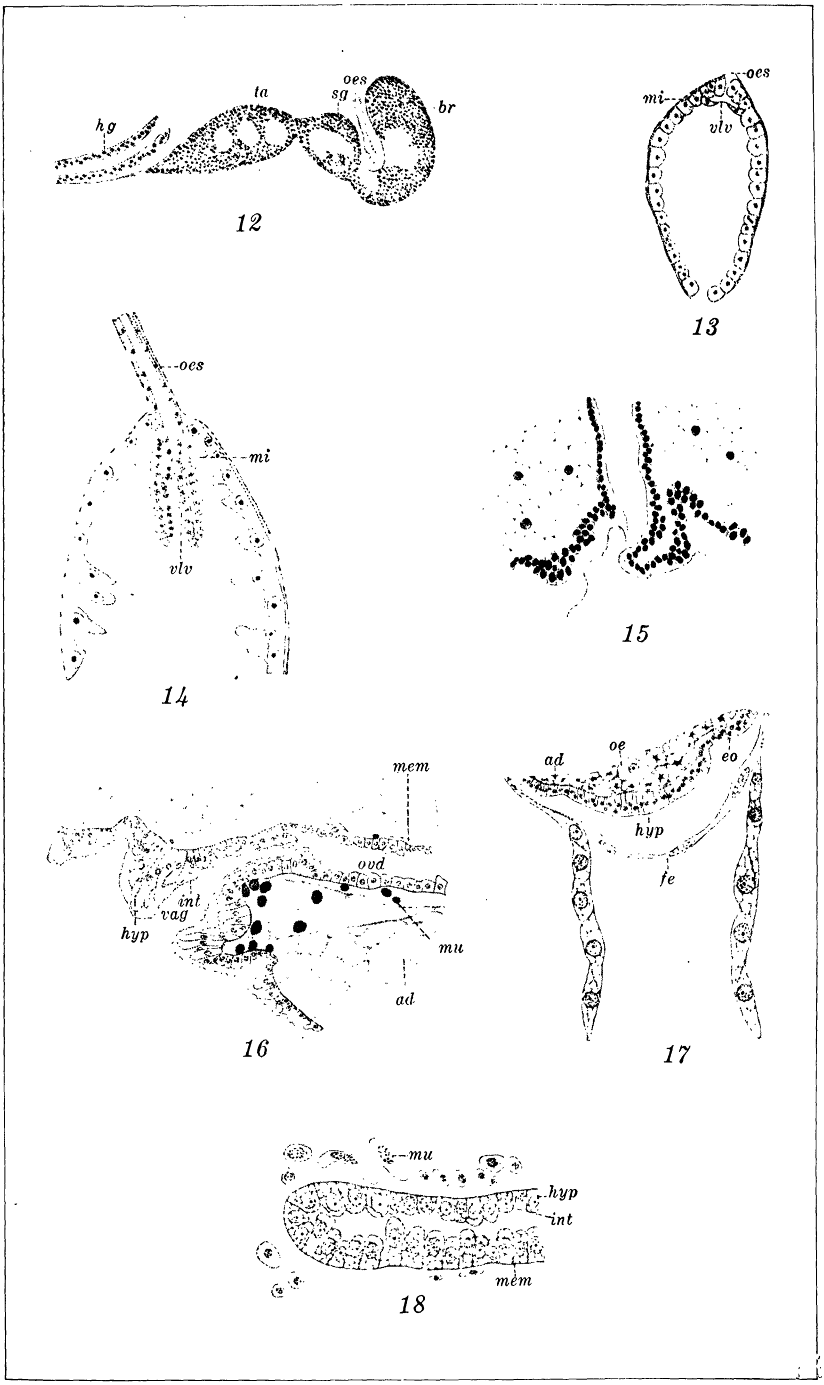
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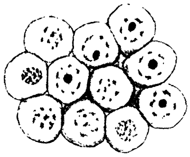

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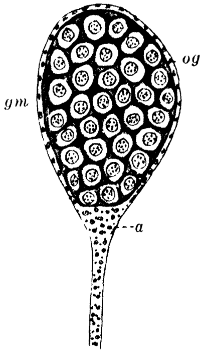

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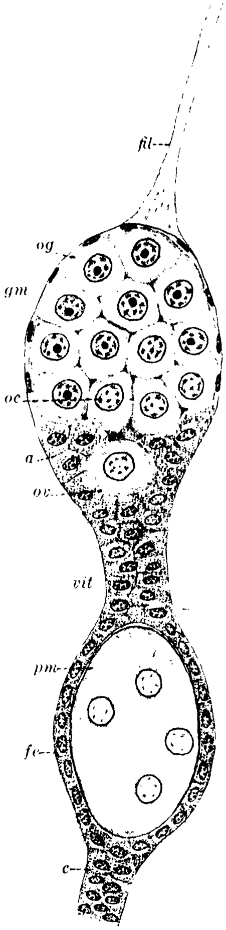

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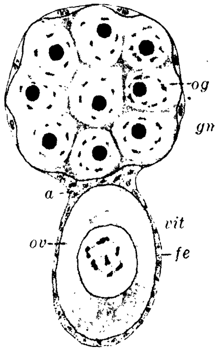

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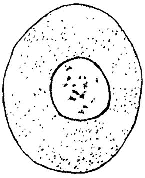

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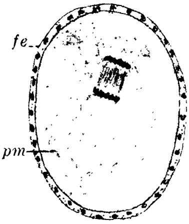

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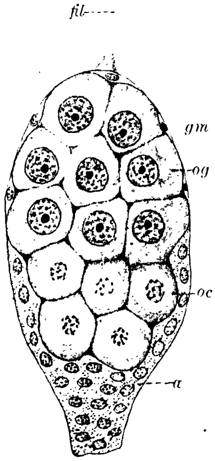

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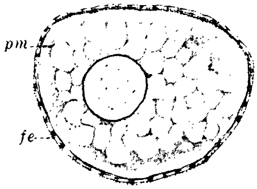

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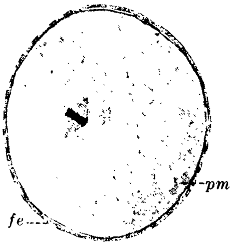

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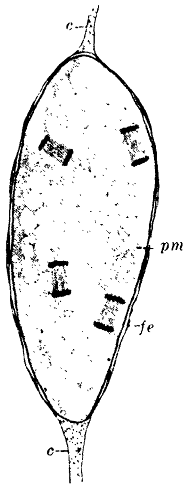

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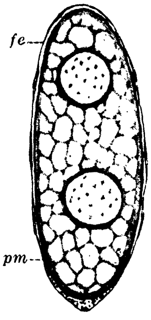

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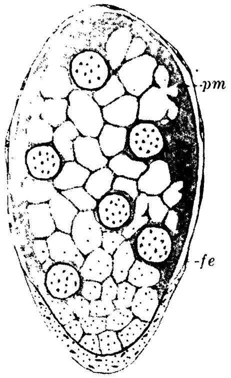

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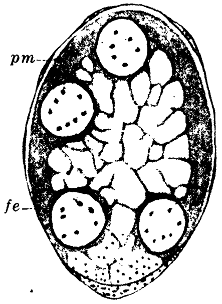

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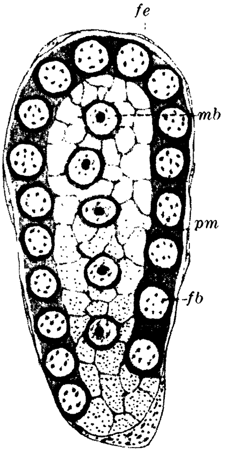

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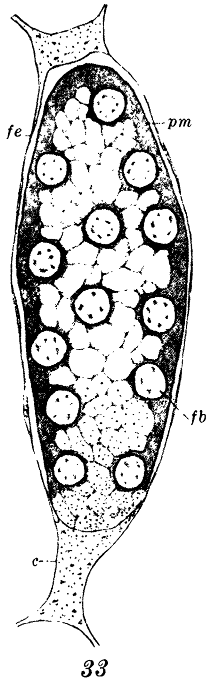

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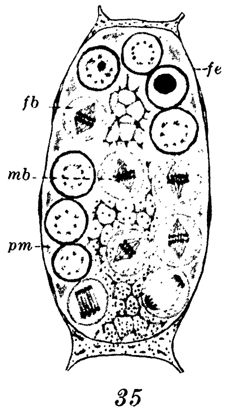

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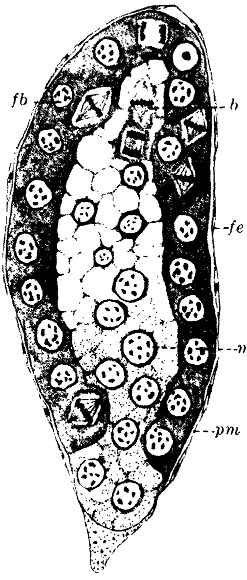

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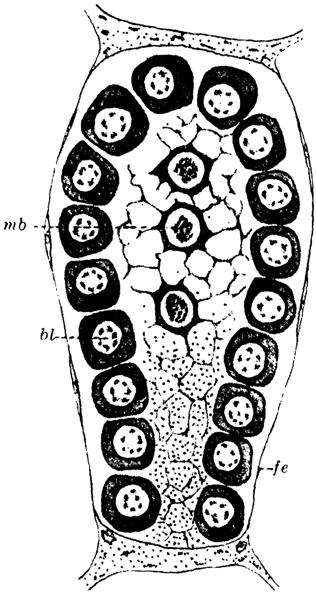

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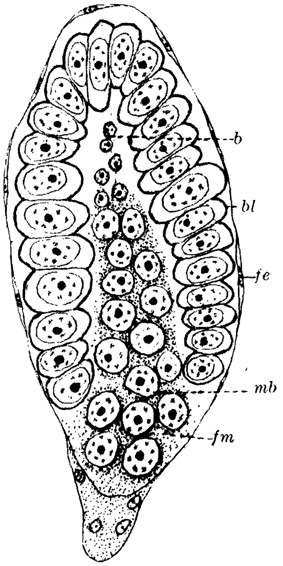

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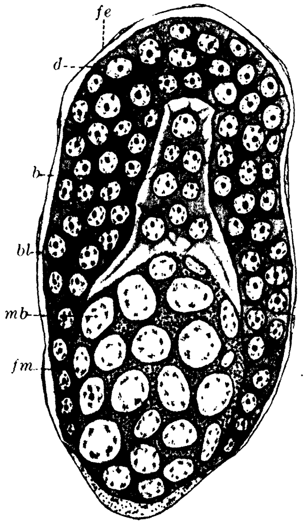

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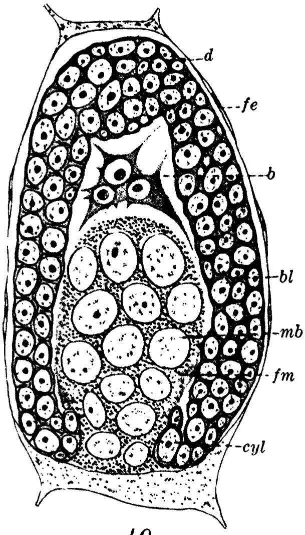

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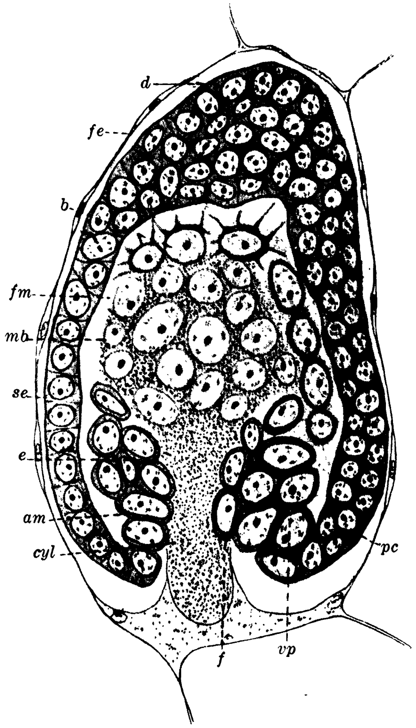

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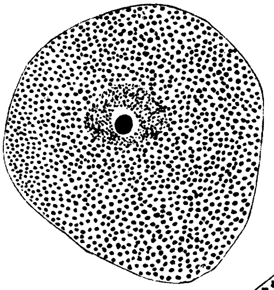

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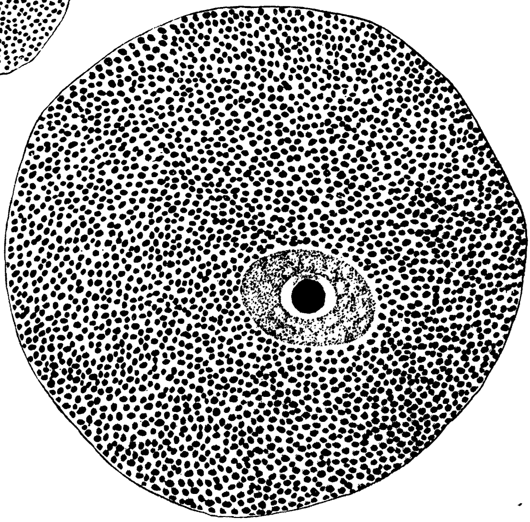

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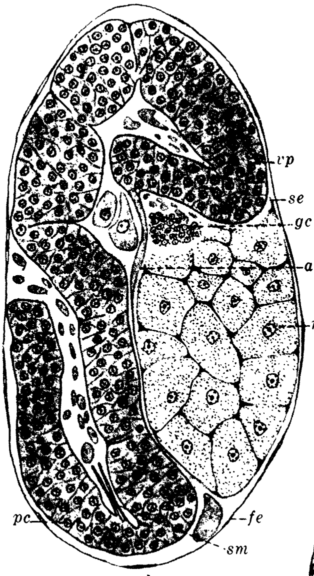

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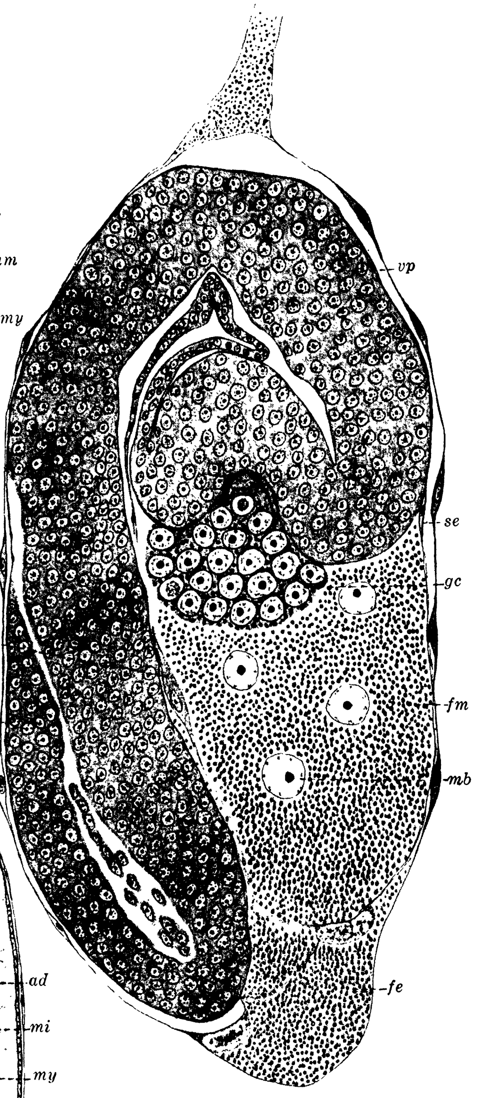

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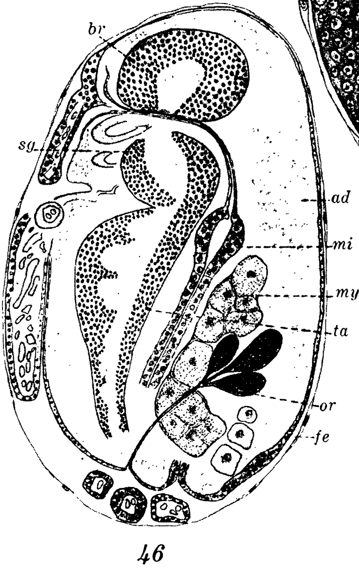

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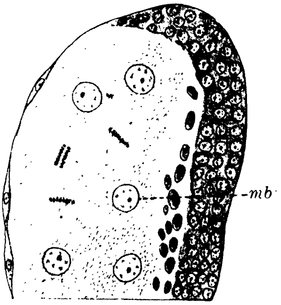

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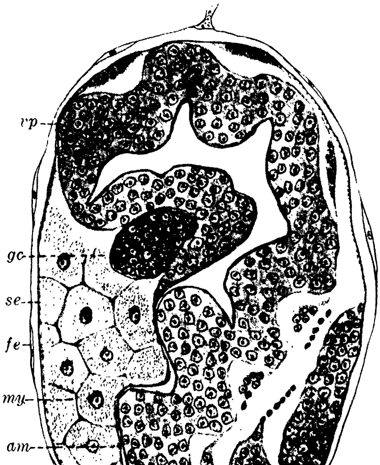

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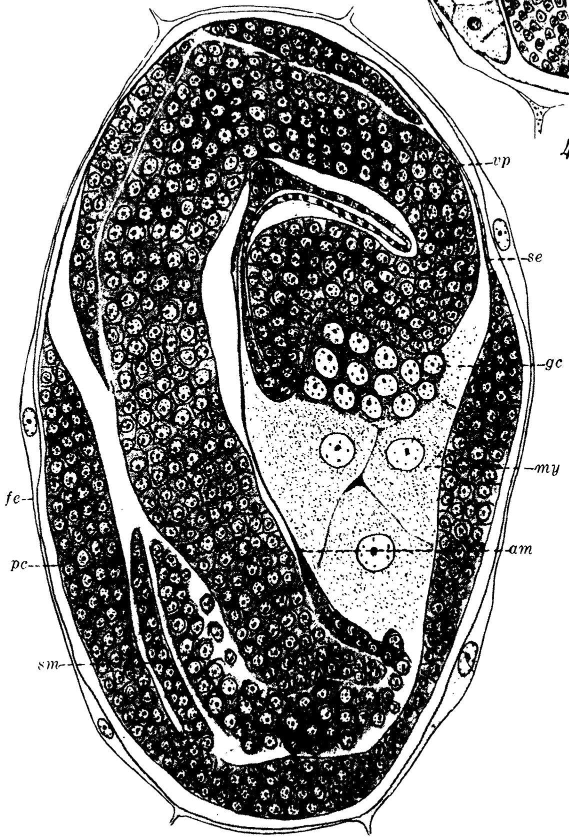

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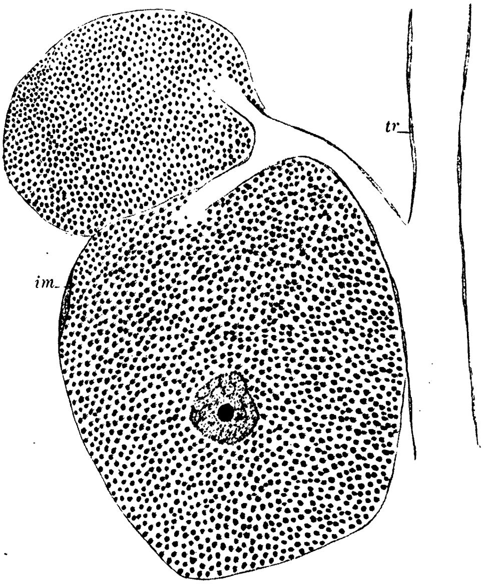

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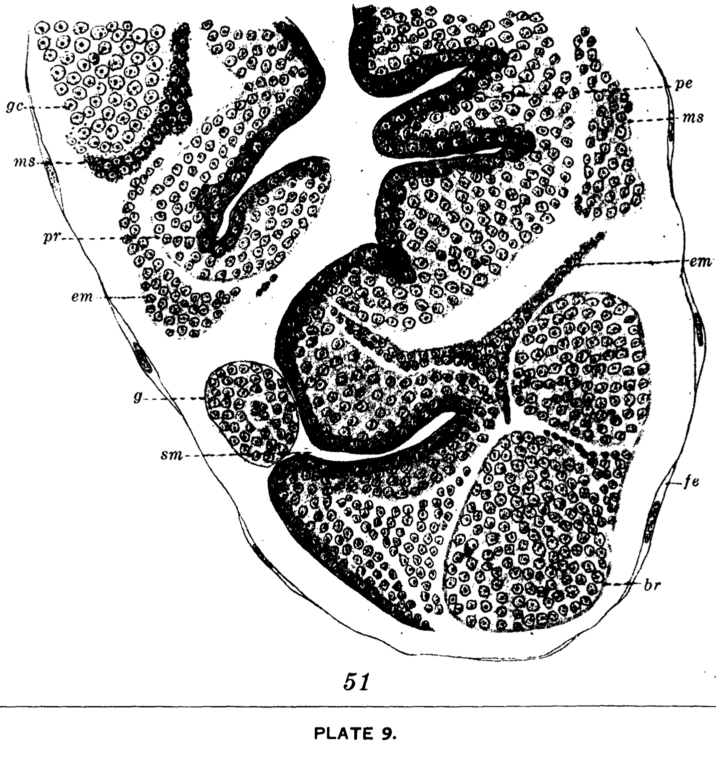

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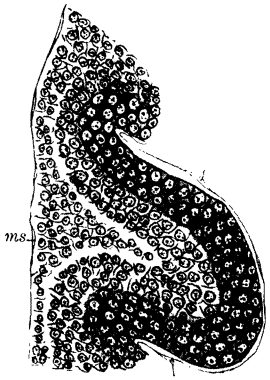

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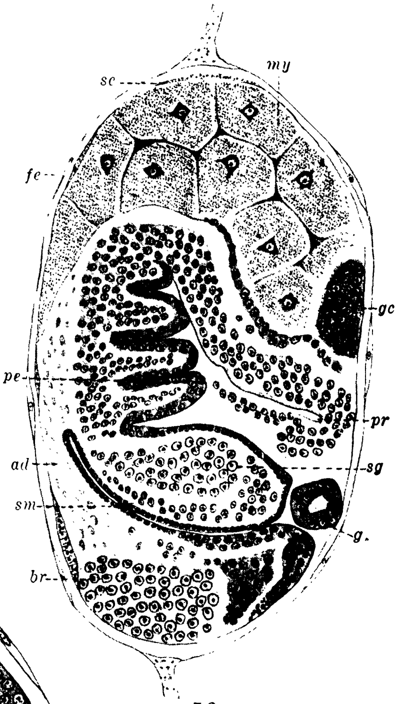

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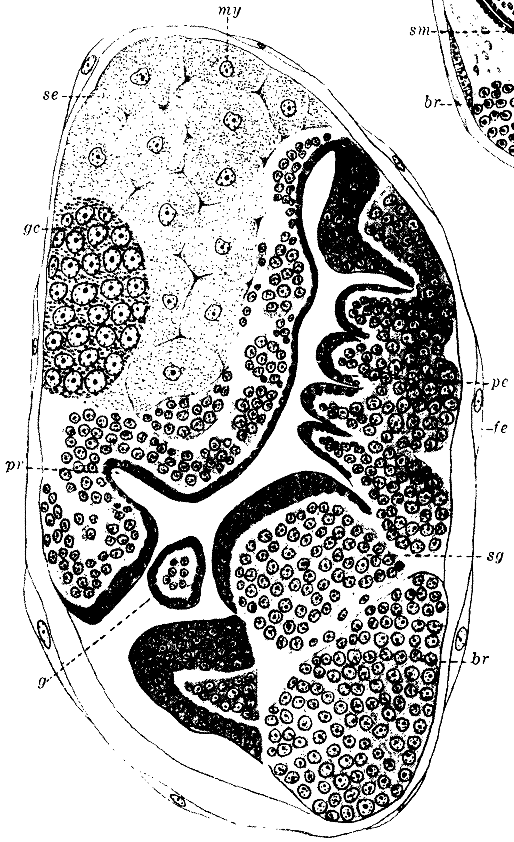

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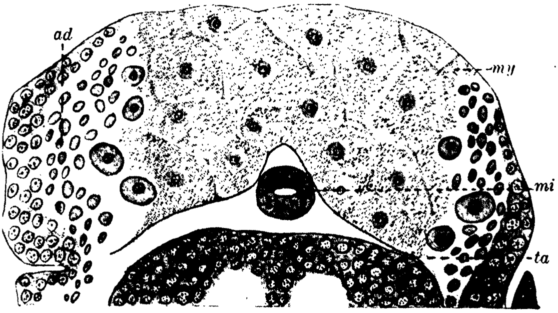

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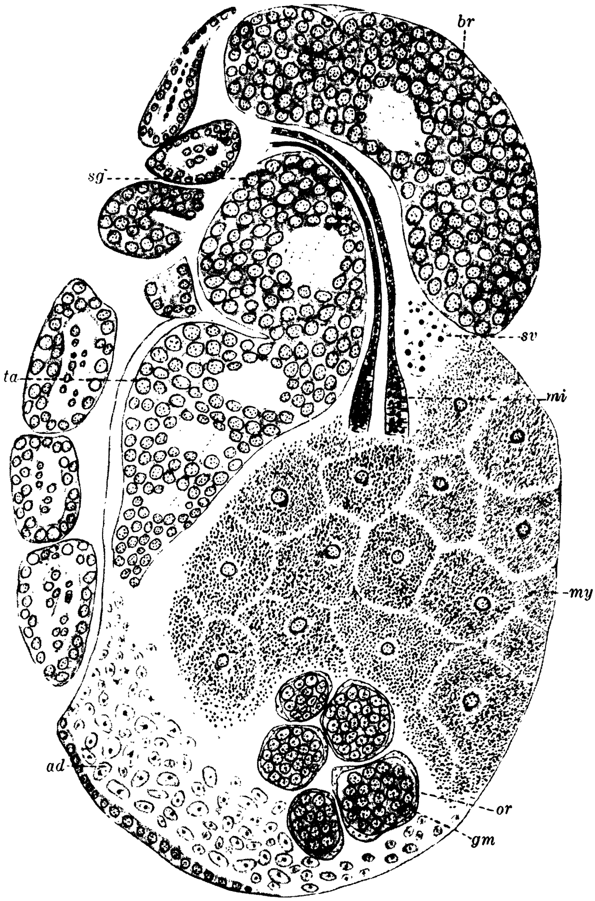

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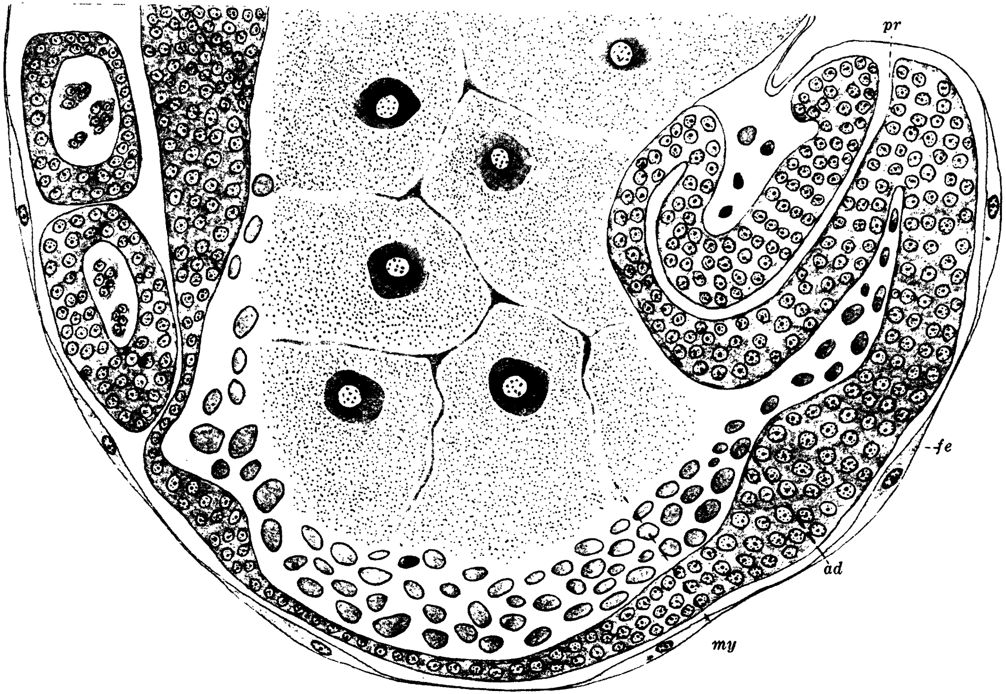

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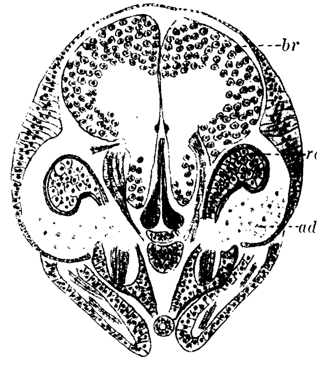

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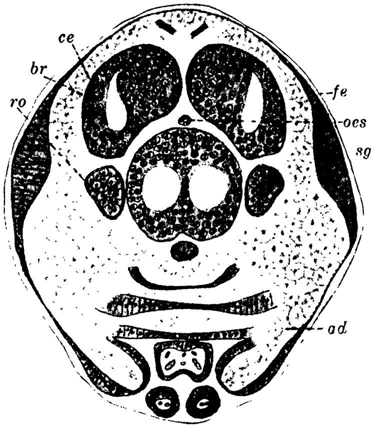

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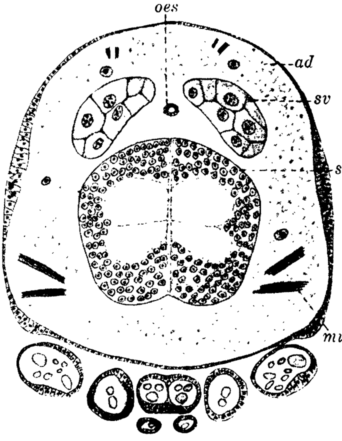

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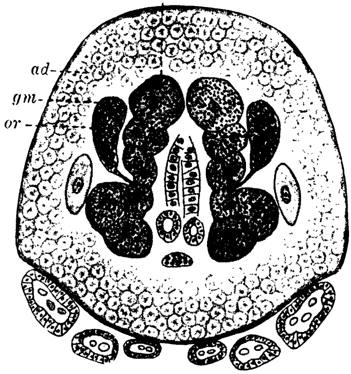

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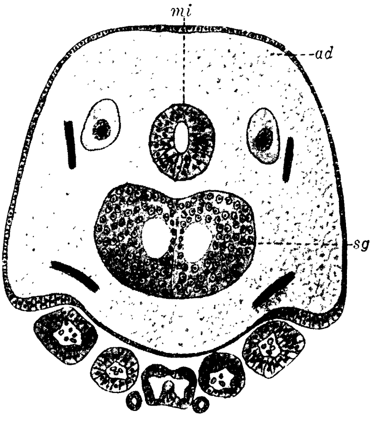

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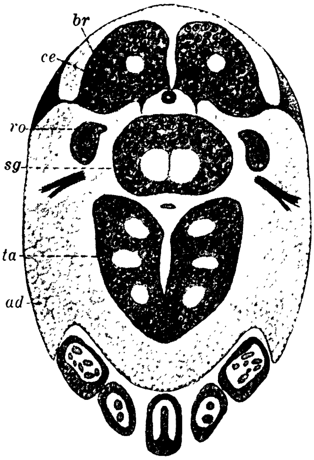

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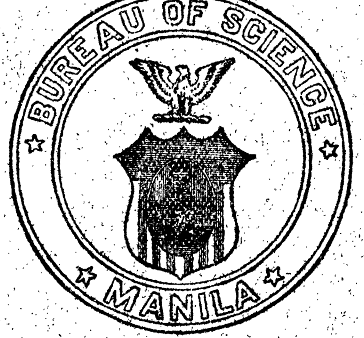

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THE PHILIPPINE
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VOL. 24 MARCH, 1924 No. 3

DISTRIBUTION OF THE TRUE FRESH-WATER FISHES IN THE PHILIPPINES

I. THE PHILIPPINE CYPRINIDÆ

By ALBERT W. C. T. HERRE

Chief, Division of Fisheries, Bureau of Science, Manila

TWO PLATES

The study of the geographical distribution of plants and animals is of great importance in at least a twofold capacity. Not only does it enable us to trace the various organisms back to their center of origin and thus throw light upon the process of evolution, but it also aids us to form a picture of a given region during various periods of geologic time. This is especially true in an archipelago like the Philippines, to the formation of which corals and volcanoes have alike contributed enormously, where many of the larger islands have been formed by the coalescence of smaller ones, and where a remarkable rôle has been enacted by great seismic disturbances and the consequent lifting or dropping of great areas of land and sea.

The exceedingly rich marine fauna of the Philippines is the same in general as that of the rest of the East Indies, though a few northern species extend from Japan as far south as the Visayas. While no light can be thrown upon the geological history of the Philippines by a study of its marine fauna, an examination of the fresh-water fishes leads to some interesting and positive conclusions.

A large number of species is found in the Philippine lakes and rivers; but, as in most islands, the majority are marine or brackish-water species, or else they spawn in salt water and spend only a part of their life in fresh water. Examples of the first are sharks, rays, sawfishes, and various ophichthyoid and murænid eels which ascend rivers 250 kilometers or more from the sea. Examples of the second group are the mullets or banak, Mugilidæ; some snappers, Lutianidæ; eels, Anguillidæ; bañgos, *Chanos chanos;* some pampanos, Carangidæ; the ten-pounder, *Megalops cyprinoides;* some Holocentridæ; many Apogonidæ; some Teraponidæ; the Kuhliidæ; *Scatophagus argus;* some pipefishes, Syngnathidæ; and many gobies. Some of those just named ascend rivers but a short distance or to some lake; but others, as the eels, mullets, and gobies, go to the smallest streams and the most remote headwaters of Luzon and Mindanao, more than 300 kilometers from the sea. All of them return to the ocean when spawning time approaches, and this annual movement, whether of adults downstream, or the influx of myriads of young at the river mouths, has given rise to very important fisheries, especially in Luzon, Mindoro, and Mindanao.

There are left then the fishes that live exclusively in fresh water. However, a little consideration will show that not all of them are true fresh-water fishes racially or geologically, although of course they are such specifically or even generically. In nearly every stream one may find curious little fishes with elongated beaks that on examination are seen to have but the lower half extended while the upper half of the beak seems to have been cut off. These are the halfbeaks, near relatives of the flying fishes, and most of the species are exclusively marine, though the ones in question spend their whole lives in fresh water. Then, too, in some streams and lakes one will find gobies which do not go down to the sea; but, since their affinities are all marine, we may regard the fresh-water halfbeaks and gobies as recent immigrants, and therefore dismiss them from consideration as having little bearing upon a study of the geological history of the Philippines and the land connections of the various islands.

The catfishes, though a fresh-water group, include a number of representatives that have adapted themselves to life in either brackish or salt water, or to living indifferently in fresh or in salt water. Omitting these, we have in the Philippines the following exclusively fresh-water fishes thus far known: One group of catfishes of two species, including the *hito,* the Clariidæ; another group of catfishes with two species, the Siluridæ; the dalag, or Ophicephalidæ, with perhaps two species; the climbing perch, *Anabas testudineus;* the Osphronemidæ with one species; and the carp family, or Cyprinidæ, with about twenty-eight species.

The hito, dalag, and climbing perch are of very doubtful utility in a study of distribution. The dalag, or haluan, *Ophiocephalus striatus,* is a fish of remarkable tenacity of life, grows rapidly to a large size, is of fair food quality, and has therefore been widely distributed by the Malays in their wanderings. As a result it occurs in all parts of the Philippines. I have authentic records of dalag being placed in remote mountain lakes by both Christian and pagan Filipinos, in one instance no other kind of fish living in the lake. Of even greater ability to live without water is the climbing perch, and it too has been carried about by Malays, though not to the same extent perhaps, as owing to its smaller size it is less desirable. The commonest of the fresh-water catfishes, the hito, *Clarias batrachus,* has also been widely distributed by man. Though it is a better food fish than the climbing perch, it is apparently not able to adapt itself to such a variety of conditions as either of the other two and hence has not such a general Philippine range.

Near the northern end of Palawan Island occur the only Philippine representatives of the Siluridæ, a family of catfishes of wide distribution in Europe, Asia, and the East Indies as far as Borneo. Our two species are closely related to others found in western Malaysia but have been separated from the rest of the world long enough to be not only specifically but also generically distinct from the Bornean-Sumatran forms from which they sprang. As they are small and of little value for food and occur in a remote and little-inhabited region they have never been distributed by man, while the geographical character of Palawan, its narrow elongate shape, and its lack of large watercourses or a central river system have effectually prevented their dispersal, so far as known.

On Cagayan Sulu Island, which is 64 kilometers from the coast of Borneo, is a species of *Trichopodus* which is confined to a small fresh-water lake there. This fish is evidently a survival of the days when Cagayan Sulu was an integral part of Borneo, and is the sole representative in the Philippines of this widespread species, which occurs from Bali and Borneo to Sumatra and Siam. Cagayan Sulu lies at the outer edge of what one may well call the Bornean continental shelf, the 100-fathom line, and the great deep of the Sulu Sea at its north has effectually prevented the further extension of this species into the Philippines.

There remains, accordingly, only the Cyprinidæ. The distribution of this family is strongly marked and corroborates to a remarkable degree the conclusions reached by a study of plants and other groups of animals. The Cyprinidæ is the largest family of fishes and is undoubtedly of Asiatic origin, with a secondary center of distribution in eastern North America. Sumatra and Borneo are the chief centers of cyprinid life in Malaysia. Cyprinids are totally lacking in Celebes and occur nowhere to the east of Borneo except in the Philippines, and nowhere east of Wallace's Line except on Lombok Island and, perhaps, on the neighboring island of Sumbawa, a single widespread species of *Rasbora* and one of *Barbodes* having succeeded in extending their range thus far eastward, probably before the formation of the straits of Lombok and Alas.

In the Philippines Cyprinidæ are apparently confined to Mindanao, Basilan, and Tawitawi, and to the Palawan biological province, where they occur on Balabac, Palawan, Busuanga, and Mindoro Islands. We are thus forced to the conclusion that there has been no land connection between Mindoro and Luzon, or else none since Cyprinidæ reached northern Mindoro. It is likewise evident that Leyte, Bohol, Cebu, and Negros have also been separated from Mindanao for a very long time, if indeed any of them except Leyte was ever connected with it. Leyte and Samar seem to have been formed by the fusion of a number of smaller islands, which have been alternately above and below sea level several times, so that Cyprinidæ would have been exterminated by salt water, if indeed the ancient islets ever possessed permanent streams of sufficient size to allow their immigration.

A study of the Cyprinidæ of Mindanao also leads to some interesting conclusions. This great land mass was once four or more separate islands, but cyprinids abound in all parts of Mindanao, whether lowland or elevated plateau regions. In the Lanao Plateau, a volcanic district with a large lake as the central feature, occur thirteen species of Cyprinidæ, although the fishes of Lake Lanao and its tributaries are separated from all other regions by the impassable barrier of Maria Cristina Falls. That this isolation took place a long time ago is shown by the fact that three genera and all of the species of Cyprinidæ living there do not occur elsewhere.

It is self-evident that the Palawan-Mindoro zoölogical province was populated by Cyprinidæ from Borneo, via Balabac. It is likewise evident that the migration must have occurred when

Palawan had a greater area than at present and probably at a time when the southern end of the China Sea was land, and a great river flowed northward, draining western Borneo and Sumatra. At this time, with larger streams in Palawan, it would have been comparatively easy for fresh-water minnows to extend their range northward. The relatively large number of endemic species in Palawan shows that this condition passed away a very long time ago.

Unquestionably, the Cyprinidæ of Mindanao entered from Borneo over a Sulu land bridge. Collections made during the summer of 1923 have shown the presence of cyprinids on Tawitawi and Basilan; but on Jolo, the only other island of the Sulu Archipelago large enough to have permanent fresh-water streams, they are apparently lacking. As far as we know, the only fresh-water fishes in Jolo are the ubiquitous dalag, and various gobies, eels, and other salt-water immigrants. The great amount of volcanic activity upon Jolo would probably have destroyed all Cyprinidæ if any ever did occur there. The endemic species at Zamboanga and on Basilan, the nearest points to Borneo, furnish proof that connection ceased a long time ago, while the numerous changes which most of the Sulu islands have undergone in elevation from time to time have destroyed any cyprinids which might otherwise have occurred there.

There are approximately one hundred eight species of Cyprinidæ known from Borneo, in contrast to the twenty-eight native Philippine species thus far collected. Of these one species is common to Borneo, Mindanao, and the Palawan *Gebiet*. One species is known only from Zamboanga and Borneo; one from the Palawan *Gebiet* and Borneo; one is confined to Mindoro, and one to Busuanga; one is thus far known from Palawan, Balabac, and Busuanga, while three species are confined to Palawan. Thirteen are limited to the plateau of the Lake Lanao region in Mindanao.

The lack of recent land connections between Formosa and the Philippines is also indicated by an examination of the fresh-water fishes of Formosa, which shows that there is no specific relationship between them and the fresh-water fishes of the Philippines and Malaysia.

Of the fresh-water fishes of Formosa more than 61 per cent are endemic, after deducting those artificially introduced or those which are wholly or partially marine or are really brackish-water forms. The nearest relatives of these endemic species are found in China, Korea, or Japan, and the majority of the fishes belonging to their genera occur in British India, Indo-China, and China.

The whole fresh-water fauna, endemic and widespread species alike, shows close relationship to the neighboring continental forms. Eleven species are of more or less general distribution, from southern China to Korea and Japan, one only on the Chinese mainland, and one only in Japan. Seven species belong to a more southerly realm, occurring in Indo-China and southern China northward to, but not beyond, the Yangtze.

An examination of the related species shows that all Formosan species with Chinese affinities have changed into more or less distinct species, while those ranging also southward into Indo-China are unchanged. Of the species not peculiar to Formosa, 80 per cent occur on the Chinese mainland. It would seem, therefore, that the fresh-water streams of Formosa were first occupied by fishes from the streams of China long enough ago to give them time to be altered, while the species with southern affinities came through southern China at a much later date and are consequently unaltered.

There is but one species recorded from both the Philippines and Formosa, and as it is also found in southern China there is no reason to believe that it reached Formosa via Luzon.

The absence of trout in the Baguio Plateau of northern Luzon, where the conditions are not greatly dissimilar to those in the highlands of Formosa in which a species of trout does occur, would seem to corroborate the statement that the Bashi Channel is an old one and that there has been no connection between Luzon and Formosa since Miocene time or even earlier. Fossil trout are known from Pliocene and Pleistocene deposits in Idaho, and from the Miocene in Bohemia. Therefore, we may be reasonably certain that if there ever was any connection between Formosa and Luzon it was broken a long time ago, so that the only land connection by which fresh-water fishes could arrive in the Philippines was that with Borneo. The true fresh-water fishes of the Philippines must then be considered as having been wholly derived from western Malaysia.

CYPRINIDÆ

This enormous family of fishes, comprising about two hundred genera and more than two thousand species, is one of the most difficult groups with which the zoölogist must deal. A few subfamilies are readily recognizable, but many of the genera are separated by characters that are not visible to the casual observer; in addition most of the species have a strong resemblance, and very careful study is necessary to distinguish them. The structure of the mouth parts, which is frequently very complicated, and the number and arrangement of the pharyngeal teeth are the chief generic characters, and often very close scrutiny is required to enable one to determine them correctly. The great similarity of form, fins, scales, and color makes the determination of species a highly critical matter in many genera, especially when they are rather small, as is often the case. The color and the proportions vary considerably between the young and the adults in many species. In many genera, the males become very brilliantly colored during the breeding season. In a great many species the male, during the breeding season, has the snout and head more or less covered with small grayish tubercles or pearly spots, outgrowths of the epidermis, which fall off later.

The Cyprinidæ are as a whole of little value as food fishes, being mostly small, very bony, and of poor flavor. One species, *Cyprinus carpio* L., Chinese carp, now of almost world-wide distribution, is in many regions of very considerable economic importance. It has become established in Pulangi River, Cotabato, and in Lake Nunuñgan, Lanao, and in time will probably become an important source of food in Cotabato and in Lanao Province, Mindanao. Goldfish, *Carassius auratus* L., are raised everywhere for ornament or as curiosities; but, although plentiful in the Philippines in cultivation, they have not become naturalized in Philippine streams. The only Philippine locality where Cyprinidæ are of real importance is Lake Lanao, where they form the main protein food of the Moros about the lake. In addition to the considerable number of species from Lake Lanao, described in this paper, one other is known to live in the lake, but as yet I have been unable to secure specimens of *bao-ulan,* as it is called in Marinao. It probably lives at a considerable depth, since it is never seen except during the coldest season after severe storms, when it comes to the surface. My informants particularly mention its great thickness from side to side and the fact that it is so fat that it fries in its own grease, not requiring the addition of any cooking fat. It is the most highly prized of the Lanao cyprinids, but is rarely obtained.

Cyprinidæ have no teeth in the jaws, but are characterized by one, two, or three rows of specialized teeth on the pharyngeals. Cyprinidæ are mainly vegetarian, but also eat more or less animal food, some species and genera being in fact predatory upon other fishes. Some Philippine species feed upon *Potamogeton* and similar water plants, some eat crustaceans, and some swallow slime and mud for the sake of its organic matter. Perhaps all of them eat worms and the eggs of other fishes, thus checking the increase of carnivorous fishes. The chief importance of Cyprinidæ in the economy of nature is that of furnishing food to the more valuable predatory fishes of rivers and lakes. Owing to their small size, profuse spawning, great swimming power, and ability to find food anywhere, they occur in vast numbers throughout their range and may be reckoned among the most successful of fishes.

Their ability to ascend hillside streams is astonishing. *Barbodes binotatus* may be found in springs hundreds of feet above the mountain stream below, to reach which it must go up a torrential brook, full of cascades and seemingly impassable waterfalls. While the common carp thrives in muddy water, most Philippine Cyprinidæ live in clear streams and lakes.

In 1840 Jacob Heckel described two species of *Cyrene,* now classified as *Dangila,* giving the locality as the Philippine Islands. I am unable to learn anything of the origin of his specimens, which were described in the Fishes of Syria, in Russegger's Reisen. It is possible that they were collected by Cuming in the Malay Peninsula or Sumatra and that the labels became mixed, as was the case with his botanical material collected at Malacca. Bleeker states that Heckel was the first to demonstrate the existence of cyprinids in the rivers of Borneo and Luzon, but adduces no proof of his use of Luzon in this connection. In the eighty-three years that have elapsed since Heckel's paper appeared nothing resembling *Dangila* has been collected in the Philippines. While this is no proof of their absence, I cannot accept them as a part of the Philippine fish fauna until their presence is demonstrated by their collection here.

FAMILY CHARACTERS

The head and body are compressed, very rarely depressed; the margin of the upper jaw is formed by the premaxillaries alone; the lower pharyngeal bones are well developed (absent only in *Gyrinocheilus*), falciform, nearly parallel with the gill arches, each bone with one to three series of teeth, four to seven in the outer row, with a smaller number in the other rows if present. The head is naked, the body scaly except in a few extra-Malaysian genera; eyes with a free margin which may form a gelatinous eyelid; barbels four, two, or absent, but present in all Philippine genera; gill openings generally wide, the membranes broadly joined to the isthmus; branchiostegals always three; gill slits four, a slit behind the fourth; pseudobranchiæ present in Philippine species; air bladder divided into two portions, the posterior of which may be reduced, the anterior in Philippine species not inclosed in bone; dorsal short or long, its origin before, opposite, or behind that of ventrals; anal short or long, its origin opposite or behind that of dorsal; arrangement of lips and jaws and their covering varying widely; no pyloric cæcæ; no adipose fin; lateral line usually complete.

In this paper the length recorded in most cases is that from the tip of the snout to the base of the caudal fin. Where the caudal fin is included it is specifically so stated.

In some species the scales of the lateral line are often irregular in number and size, due apparently to the interpolation of small scales which replace larger ones that have been injured or lost. In such cases the extra number has not been given as a diagnostic specific character but, instead, the number that is deemed typical of the species. In giving the transverse series of scales, as in the formula $\frac{4.5}{2.5}$ the number 4.5 signifies that there are 4.5 rows of scales between the origin of the dorsal fin and the lateral line, while the other number, 2.5, means that there are 2.5 rows of scales between the lateral line and the anus; the lateral line itself is not counted. It is necessary in examining specimens to count the lateral line on both sides, since there is often a marked discrepancy between the two sides.

The number of dorsal spines is given incorrectly by many authors; the first dorsal spine is often very small, but is plainly seen if care is used in looking for it. Nearly all Philippine species of *Barbodes* have four dorsal spines, and not three, as often given.

Key to the subfamilies of Philippine Cyprinidæ.

a^1. All or part of abdomen compressed to an edge.................... **Abramidinæ.**

a^2. Abdomen rounded or sometimes flattened, but not compressed to an edge.

- b^1. Lower jaw generally with a knob at symphysis, fitting in a notch in the upper one; dorsal without osseous spine, its origin behind that of ventrals; lateral line abruptly bending downward, if complete running along lower half of tail............................ **Rasborinæ.**
- b^2. No knob at symphysis of lower jaw; dorsal usually with osseous spine, its origin before or above that of ventrals; if behind them, the dorsal has a strong osseous spine; lateral line running in the middle of tail.. **Cyprininæ.**

ABRAMIDINÆ

The oblong body elongate to very elongate, and compressed to greatly compressed; abdomen or a part of it compressed below to a sharp edge.

Dorsal short, with seven to ten branched rays, and opposite to space between ventrals and anal or to anal; it may be without an enlarged spine or the third one may be bony and smooth (in one case serrated behind); anal moderate to very long, with twelve to forty-eight branched rays; ventrals absent in one genus, present in all others; pectorals more or less elongate; caudal forked; mouth terminal, subinferior or strongly oblique with prominent lower jaw and a knob sometimes present at symphysis, a pair of maxillary barbels in Philippine species, none present in other genera; scales small to medium, with the lateral line in the lower half of tail or in the middle, gill openings reach to below eye or preoperculum; pharyngeal teeth in a single, double, or triple series.

Represented in the Philippines by a single genus.

Genus **NEMATABRAMIS** Boulenger

Nematabramis BOULENGER, Ann. & Mag. Nat. Hist. VI 13 (1894) 249.

Mearnsella SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1908) 231.

The oblong body very strongly compressed laterally, the belly having a sharp, cutting edge; dorsal profile slightly convex, the nape more or less concave; ventral profile strongly convex; mouth moderate, oblique, with protractile upper jaw; lower jaw slightly projecting, with a more or less developed knob at symphysis, which fits into a shallow notch in upper lip; a pair of long thin maxillary barbels; eye with a free orbital margin; dorsal short, without osseous spines, its origin opposite to that of anal, the latter with twelve to eighteen rays and much longer than dorsal; ventrals with five or six branched rays, separated by one scale from lateral line; pectorals longer than head; caudal deeply notched; lateral line bent down abruptly behind pectoral fin and continued backward near ventral profile; pseudobranchiæ present; gill rakers short; branchial opening reaching beneath eye; pharyngeal teeth hooked, in two series, 5, 4 to 4, 5.

This genus is known only from the Philippines and Borneo.

Key to the Philippine species of Nematabramis.

a^1. Barbels shorter than head.
  b^1. Depth 2.6 in length.. **N. verecundus.**
  b^2. Depth 3.25 to 4 in length.. **N. alestes.**
a^2. Barbels one and one-half times to twice as long as head.... **N. everetti.**

Nematabramis verecundus[1] sp. nov.

Dorsal II, 8; anal III, 12; pectoral I, 9; ventral I, 5; lateral line, 30 on one side, 32 on the other; transverse line, $\frac{6.5}{1}$; scales from nape to dorsal, 22; scales on caudal peduncle, 13.

Body elongate, the dorsal profile nearly straight, the ventral profile uniformly convex from chin to tail; depth $2\frac{5}{8}$ in length, head 3.5; eye 4 in head, 1.5 in interorbital space, and longer than snout; mouth strongly oblique, lower jaw prominent, its tip higher than upper margin of pupil, with very small symphysial knob fitting into a shallow curve in the protractile upper lip; posterior end of maxillary lies beneath anterior margin of eye; maxillary barbels $\frac{5}{8}$ as long as head, hardly extending to middle of opercle; origin of dorsal more than twice as far from tip of snout as from caudal, slightly behind that of anal, and behind the nineteenth scale of lateral line, its height $1\frac{5}{7}$ in head; origin of anal opposite eighteenth scale, its height $1\frac{1}{8}$ in head; pectoral long, pointed, extending well beyond base of ventral, $1\frac{1}{12}$ times head; ventrals small, less than half the head and covering not quite 0.7 of the distance to anus; length of caudal peduncle 1.55 in head, depth 1.9 in its length and 3 in head; caudal fin damaged.

Color in alcohol brownish, darker above, pale yellowish gray on sides and belly; a median blackish brown stripe from nape to caudal; top of head dusky; a dark bar from shoulder to caudal, with a black line more prominent posteriorly and terminating in a triangular black spot just before caudal fin; a large dark blotch on side above anterior portion of pectoral and two smaller blotches below and anterior to it; scales outlined or specked by dark dots; anal dusky, especially anteriorly; posterior margin of caudal dusky; other fins more or less dark dotted or fading out to clear; opercle apparently with a dark spot, but really colorless and transparent, the dark gills showing through.

[1] *Verecundus*, modest.

Here described from the type and only specimen, 42 millimeters long, obtained by me in Titunod River, Kolambugan, Lanao Province, Mindanao.

Nematabramis alestes (Seale and Bean).

Mearnsella alestes SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 231, fig. 2.

Nematabramis alestes JORDAN and RICHARDSON, Check List of Philippine Fishes (1910) 12.

Dorsal II, 8–9; anal III, 12–13, very rarely 14; pectoral I, 11–12; ventral I, 6–5; lateral line, 34–37; transverse series, $\frac{5.5\text{–}7.5}{1.5}$; scales from nape to dorsal, 22–23; scales around caudal peduncle, 13–14, more rarely 12.

Body oblong, much compressed, dorsal region elevated in a low curve, or convex from snout to dorsal, top of head straight, head usually bent upward with a slight depression at nape; the ventral profile strongly convex from chin to caudal fin; depth from 3.25 to 4 in length, head from 3.75 to 4.4; eye 3.4 to 4.2 in head, equal to or 1.3 in snout, and 1.4 to 1.8 in interorbital space, which is depressed centrally and has six or seven pairs of transverse marginal bony ridges; mouth large, terminal, oblique, posterior margin of maxillary extending beyond anterior of eye; upper lip thin, slightly protractile, with a small median curve or notch into which fits a small knob on tip of lower lip; lower jaw projecting or the jaws equal; maxillary barbels very slender, from less than $\frac{1}{2}$ to $\frac{2}{3}$ as long as head, not extending beyond middle of operculum; dorsal opposite anal, its origin behind that of anal and behind twentieth or opposite twenty-second scale of lateral line, its height $1\frac{1}{3}$ to $1\frac{1}{2}$ in head; distance from dorsal to caudal more than half the distance from dorsal to tip of snout; anal slightly higher than dorsal, opposite nineteenth or twentieth scale, its length nearly equal to or 0.75 that of head; pectoral pointed, 0.1 or 0.2 longer than head, tip extending beyond origin of the small ventrals, which are from 1.6 to 1.7 in head and from 0.68 to 0.8 as long as distance from ventral origin to anus; length of caudal 1.4 to 1.66 in head, its least depth $1\frac{1}{3}$ to 1.66 in its length or 2.3 to 2.4 in head; caudal slightly to considerably longer than head, broadly notched, the lower lobe larger, the shortest rays half or more than half as long as the longest rays.

Color of fresh alcoholic specimens dusky above, paler below to pale yellowish on sides and belly with a bright silvery luster over all; a wide dark silver lateral band from opercle to base of caudal, where it is more or less enlarged; an obscure black blotch in band over anterior portion of pectoral, with one to several vertical dark marks below it; top of head blackish; a very dark line from nape to base of caudal along middle of back; opercle and preopercle shiny silver; scales more or less faintly outlined by dark dots; dorsal, anal, margins, and posterior margin of caudal more or less dusky or blackish; other fins colorless or the rays faintly dusky.

Color in alcohol after fifteen years yellowish, dark brown above, paler to whitish on belly, with a silvery luster over all, operculum and preoperculum bright silver; a dark silvery lateral stripe from opercle to caudal, ending in a circular or triangular dark spot; three more or less well developed vertical dark marks in the lateral bar above anterior half of pectoral; traces of a median dark line on back from nape to dorsal; scales faintly outlined with dark dots; membranes of dorsal, anal, and caudal darkened by minute dots; other fins colorless.

Here described from fifteen specimens, 58 to 96 millimeters long, collected by Alvin Seale at Zamboanga, the type locality, in 1908, and sixteen specimens, 45 to 82 millimeters long, collected by Mr. Seale at Puerto Princesa, Palawan, in 1908; eight specimens, 36 to 48 millimeters long, from a pool in the dried bed of a stream near Taytay, Palawan, collected in 1913; and twelve specimens, 66 to 97 millimeters long, collected at Concepcion, Busuanga, by G. A. Lopez, in 1922.

This species is subject to considerable variation in the scales and fin rays. While it is close to both *N. everetti* and *N. steindachneri*, it may be distinguished at a glance from either by the much shorter barbels and the smaller number of rays in the anal fin.

This species is known only from Zamboanga, Basilan, Palawan, and Busuanga, but probably occurs on Tawitawi and Balabac, and in northern Borneo.

Since I wrote the above G. A. Lopez, of the Bureau of Science, has obtained the following specimens on Basilan Island: Eight specimens, 64 to 90 millimeters long; six specimens, 50 to 75 millimeters long, from Lamitan River; eleven specimens, 32 to 83 millimeters long, from Burakan River; two specimens, 51 and 66 millimeters long, from Busay River; and sixteen specimens, 40 to 87 millimeters long, from Balactasan River.

Nematabramis everetti Boulenger.

> *Nematabramis everetti* BOULENGER, Ann. & Mag. Nat. Hist. VI 13 (1894) 250, 15 (1895) 187; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 46.

Dorsal II, 8, 9–12; anal III, 16–18; pectoral I, 10; ventral I, 5; lateral line, 35–37; transverse line, $\frac{6.5\text{–}7.5}{1.5\text{–}2}$ (at origin of dorsal); scales from nape to dorsal, 24; scales on caudal peduncle, 12.

Height 3.25 to nearly 3.75, about 4.6 in length with caudal; head 4.3 to 4.5, 5.4 in length with caudal. Eye 3.6 to 4, shorter than snout and interorbital space. Barbels one and a half times to twice as long as head. Origin of dorsal above twentieth scale of lateral line, twice as far from end of snout as from base of caudal. Height of dorsal slightly more than length of head without snout. Origin of anal below eighteenth scale of lateral line, its height somewhat more than that of dorsal. Ventrals a little nearer to end of snout than to base of caudal. Pectorals $1\frac{1}{3}$ times as long as head, extending beyond base of ventrals. Least height of caudal peduncle more than twice in length of head and 1.7 in its own length. Length, 110 millimeters.

Color pale, with a silvery lateral stripe. Description compiled from Boulenger and from Weber and Beaufort. Originally described from Borneo.

I have included this species on the strength of Boulenger's record cited above, but its presence here seems doubtful. It is impossible to state whether the specimens named by Boulenger were collected on Balabac or on Palawan.

RASBORINÆ

The compressed, oblong or elongate body more or less rounded on ventral side of belly; no bony dorsal spine, fin short or of moderate length, with from six to sixteen soft rays, its origin behind that of ventrals; anal with from five to seventeen branched rays, its origin usually below posterior end of dorsal; pectorals and ventrals always present and caudal forked. Mouth terminal, oblique, with lower jaw usually projecting and with a knob at symphysis which fits into a notch in upper jaw; a pair of rostral and maxillary barbels may be present, or the maxillary or both pairs may be vestigial or absent. The scales may be of small, medium, or large size; if the lateral line is present it bends abruptly downward, and if complete it runs along the lower half of tail. Gill openings extend forward to below preoperculum or to below eyes. Pharyngeal teeth lanceolate or hooked, in one or three rows.

Of the four East Indian genera known, only the one given below is represented in the Philippines. It may be recognized by the total absence of barbels, the others having at least one pair present, though it may be in a rudimentary form.

Genus **RASBORA** Bleeker

Rasbora Bleeker, Nat. Tijdschr. Ned. Ind. 20 (1859–60) 435.

Body oblong or elongate, with a rather small, oblique mouth, and a prominent lower jaw with a knob at symphysis which fits into a more or less evident notch in upper jaw. There are no barbels. Dorsal has seven or eight branched rays; its origin is between that of ventrals and anal; the latter fin is short and has five branched rays. Scales of medium or large size. The lateral line bends downward abruptly, and if complete runs along lower half of caudal peduncle. Gill openings reach below preoperculum and the gill membranes are connected with the isthmus opposite pupil of eye; pseudobranchiæ present. The hooked pharyngeal teeth are in three rows, 5 to 4, 4 to 2, 1 or 2–1 or 2, 2 to 4, 4 to 5.

This genus ranges from the Philippines and Sumbawa, throughout eastern and southern Asia; one species is found in Africa. Four species are known from the Philippines.

Key to the Philippine species of Rasbora.

a^1. Lateral line incomplete, not extending beyond anal........ **R. taytayensis.**
a^2. Lateral line complete and reaching caudal.
  b^1. Seven rows of scales between lateral lines over middle of caudal peduncle; lateral line, twenty-six; scales between nape and dorsal, twelve .... **R. lateristriata.**
  b^2. Nine rows of scales between lateral lines over middle of caudal peduncle.
    c^1. Scales in lateral line, twenty-six; scales between nape and dorsal, ten .... **R. punctulatus.**
    c^2. Scales in lateral line, twenty-eight to thirty-two; scales between nape and dorsal, twelve to thirteen.
      d^1. Origin of dorsal midway between tip of snout and caudal; least depth of caudal peduncle 1.9 to 2 in its length; maxillary not reaching eye........ **R. argyrotaenia.**
      d^2. Origin of dorsal nearer caudal than tip of snout; least depth of caudal peduncle 1.44 to 1.77 in its length; maxillary extending to front margin of eye........ **R. philippina.**

Rasbora taytayensis sp. nov.

Dorsal II, 7; anal III, 5; pectoral I, 12; ventral I, 7; lateral line incomplete, 15 to 17; longitudinal series of scales, 26, 28; transverse series, $\frac{4.5}{1}$; scales from nape to dorsal, 11.

Dorsal profile nearly straight, the back but little arched, ventral profile strongly convex; depth 3.25 to 3.57 in length; head equal to depth or shorter, 3.5 to 3.77 in length; eye large, 3 to 3.5 in head and from $1/7$ to $\frac{1}{3}$ longer than the short blunt snout; interorbital space flat, 2.2 to 2.55 in head, from 0.25 to more than $\frac{1}{3}$ wider than eye diameter; mouth rather wide, very oblique, the posterior margin not reaching eye; lips thin, subequal or the lower projecting, with a prominent knob at symphysis fitting into a median notch in upper lip; origin of dorsal behind the tenth scale of the lateral line, nearer to caudal than to tip of snout, but much nearer ventrals than anal, its height slightly less than length of head; pectoral not reaching ventral, 1.1 to 1.3 in head; origin of ventral opposite ninth scale of lateral line, its tip about reaching anus; anal height 1.2 to 1.36 in head; length of caudal peduncle 1.27 to 1.37 in head, its least depth 1.25 to 1.57 in length; caudal deeply forked, longer than head, the longest rays of the pointed lobes less than twice as long as the shortest rays, nine rows of scales between the lateral lines, counting over the back just in front of dorsal; the lateral line never extends beyond anal and often does not reach it.

Color in alcohol silvery brown, very dark above, paler below: a narrow black stripe on back from nape to caudal; a blackish or dark silver line or band along the side on posterior half of body, with a black circular spot at base of caudal; below this is a broad dark band, beginning behind eye, best developed anteriorly, and composed of many fine dots; a dark brown bar behind posterior margin of gill opening; scales margined with many fine dark spots; a band of many black spots along base of anal; fins colorless or their rays more or less dark dotted.

Here described from six spawning females, 38 to 50 millimeters long, collected in a pool in the bed of a dry stream on the trail between Taytay and Malampaya Sound, Palawan, in 1913. I have also examined one hundred sixty-four specimens, 18 to 45 millimeters long, collected from a creek near Taytay, Palawan, at the same time. This species is nearest to *Rasbora semilineata* Weber and Beaufort, but is quite distinct.

Rasbora lateristriata Bleeker.

Leuciscus lateristriatus BLEEKER, Nat. Tijdsch. Ned. Ind. 7 (1854) 94.
Rasbora lateristriata BLEEKER, Ichth. Arch. Ind. Prod. 2 Cyprini (1860) 441; Atlas Ichthy. 3 (1863) 121; GÜNTHER, Cat. Fishes Brit. Mus. 7 (1868) 195; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 76.

Dorsal II, 7; anal III, 5; lateral line, 26; transverse line, $\frac{4.5}{}$; scales between nape and dorsal, 12; scales between lateral line over middle of caudal peduncle, 7.

Depth 4.5 times, head 3.85 times in length; eye 3.5 times in head, $1\frac{1}{3}$ times in the broad interorbital space, and nearly as long as snout which goes 3 times in head; mouth strongly oblique, its anterior end as high as upper margin of pupil; maxillary extends posteriorly beneath anterior margin of eye; origin of dorsal opposite tenth scale of lateral line in my specimen ("opposite to 11th lateral scale or one scale less or more," according to Weber and Beaufort) and nearer caudal than tip of snout; height of dorsal less than depth of body, about $1\frac{1}{3}$ in length of head and equal to length of pectoral; origin of ventrals behind eighth scale of lateral line and nearer anal than opercle; least depth of caudal peduncle twice in its length; caudal deeply and broadly forked, badly broken in my specimen.

Color in alcohol.—Whitish to yellowish on sides and below, scale margins more or less indicated by broad bands of minute dark dots; dorsal region dark brown; top of head blackish brown and a narrow blackish stripe from nape to caudal fin; a silvery black spot on opercle; a narrow silvery black stripe along side, beginning behind opercle, darker and more conspicuous along posterior half, bordered above and especially below by a broad band composed of minute dark specks.

A single specimen, 81 millimeters long, was obtained in Malum River, Tawitawi, by G. A. Lopez, September 21, 1923.

This species is split into several well-marked varieties by Weber and Beaufort, and occurs from Sumatra to Borneo, Lombok, and Sumbawa. My specimen agrees fairly well with Weber and Beaufort's description of this widely distributed species.

Rasbora punctulatus Seale and Bean.

Rasbora punctulatus Seale and Bean, Proc. U. S. Nat. Mus. 33 (1907) 232, fig. 3.

Dorsal II, 7; anal III, 5; lateral line, 26; transverse line, $\frac{5.5\text{–}4.5}{1\text{–}1.5}$; scales between lateral lines over middle of caudal peduncle, 9; scales between nape and dorsal, 10; pharyngeal teeth, 5, 3, 2–2, 3, 5.

Body slender, the dorsal profile more strongly arched than the ventral. Depth 3.1 to 3.5 in length, head 3.75 to 4.16; eye 2.8 to 3 in head, equal to the flat interorbital and longer than the short blunt snout, which is 4 to 4⅔ in head in my specimens, 3.5 in the type; mouth oblique, its upper end upon or above a level with upper border of pupil; lips thin, equal, the upper one conspicuously notched to receive the projecting pointed tip of lower jaw; origin of dorsal midway between tip of snout and caudal fin, or a little before or behind the middle, and opposite ninth or tenth scale of the lateral line, its height equal to or 1.25 in head; pectoral equal to or 1.1 in head; tip sometimes reaches ventral but usually not; origin of ventral opposite eighth or ninth lateral-line scale, much nearer anal than operculum, the tip reaching anus; height of anal 1.3 to 1.5 in head; length of caudal peduncle 1.25 to 1.4 in head, its least depth 1.4 to 1.7 in its length; caudal deeply forked, with narrow pointed lobes, the longest rays a third longer than head and about twice as long as the shortest rays.

Color after fifteen years in alcohol yellowish brown with a silvery luster over all; a broad dark silver band from opercle to caudal fin, scales broadly outlined by minute dark dots; fins colorless, or pectoral rays minutely dark dotted.

Here described from twenty-eight specimens, 39 to 56 millimeters in length, collected by Alvin Seale at the type locality, Zamboanga, Mindanao.

I have recently received thirty-eight specimens from Basilan Island, varying in length from 27 to 65 millimeters; twenty-eight are from Balactasan River and six from Burakan River. The color of fresh formalin specimens was brownish above, becoming whitish on the belly, with a longitudinal blackish band or line from the shoulder along the side to the middle of the caudal; the scales were mostly outlined by broad bands of fine dark dots; the fins were suffused with red.

Rasbora argyrotaenia Bleeker.

Leuciscus argyrotaenia BLEEKER, Verh. Bat. Gen. **23** (1850) Ichth. Midden- & Oost-Java, 21.

Rasbora argyrotaenia BLEEKER, Ichth. Arch. Ind. Prodrom. **2** Cyprini (1860) 448, Atlas Ichth. **3** (1863) 123, pl. 132, fig. 3; GÜNTHER, Cat. Fishes Brit. Mus. **7** (1868) 195; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **3** (1916) 61.

Rasbora everetti BOULENGER, Ann. & Mag. Nat. Hist. VI **15** (1895) 187.

Dorsal II, 7; anal III, 5; pectoral I, 12–14; ventral I, 8; lateral line, 28–32; transverse line, $\frac{4}{1 \text{ or } 2}$; scales from nape to dorsal, 12–13; scales between lateral lines on caudal peduncle, 9, rarely 8; pharyngeal teeth, 5, 3, 2–2, 3, 4 and 5, 3, 2–1, 4, 5.

Body elongate, back but little arched or nearly straight, ventral profile convex; depth 3.7 to 4.3 in length, head 3.5 to 4; eye equal to snout or nearly so, 3.1 to 3.57 in head; interorbital space flat, hardly exceeding eye or 1.4 times eye; cleft of mouth oblique, its upper end about as high as upper margin of pupil, maxillary not extending as far posteriorly as anterior margin of eye; lips thin, equal, the lower one not projecting, the upper one moderately protractile, with a small median notch into which the knob at mandibulary symphysis fits; lower jaw comparatively heavy, prominent, sometimes with an external projecting knob at symphysis; origin of dorsal midway between tip of snout and caudal, opposite twelfth scale of the lateral line, nearer to ventral than anal, its height 1.25 to 1.5 in head; pectoral 0.8 to 0.85 as long as head, or as long as from tip of snout to posterior margin of preopercle, or more, but never as long as head and not reaching ventral; origin of ventral behind tenth lateral-line scale, slightly nearer anal than operculum; tip not reaching anus; length of caudal peduncle from 0.71 to 0.92 of head, its least depth 1.9 to 2 in its length; the deeply forked caudal fin as long as or longer than head, its longest rays twice or a little more or less than twice the shortest rays; the pharyngeal teeth subject to much irregularity.

Color in alcohol yellowish brown with a silvery sheen over all, darker above and pale or whitish beneath; a narrow blackish stripe along back from nape to caudal fin; a broad blackish or bluish silver band from shoulder along middle of side, ending just before caudal fin, widest on posterior half of body; operculum more or less bright shining silvery; scales more or less margined by brown lines or dots; fins colorless or their rays punctulated with minute dark dots, the posterior border of caudal narrowly margined with blackish.

The above description is based upon thirty-nine specimens, 68 to 109 millimeters in length, obtained at Langbuan, Busuanga, in September, 1922. While most of them are mature, none are in spawning condition though the eggs and sperm are somewhat developed in some. I have also examined several hundred specimens, mostly 16 to 30 millimeters long, but ranging up to 100 millimeters, collected by Prof. A. L. Day in Lake Manguao, northern Palawan, in May, 1913; and twelve specimens, 48 to 65 millimeters in length, collected by Alvin Seale at Puerto Princesa, Palawan, in 1908.

While *R. everetti* Boulenger differs somewhat from the published accounts of *R. argyrotaenia,* I follow Weber and Beaufort in placing it in the synonymy. This species undoubtedly occurs throughout the Calamianes and Palawan; Boulenger's specimens probably came from Puerto Princesa. It is to be expected from Mindoro, though it may not have gone so far north, and must be in Balabac. Elsewhere it is found from Borneo to Java, Sumatra, the Malay Peninsula, Siam, and Annam. This handsome species is said to reach a length of nearly 170 millimeters. I have omitted much of the synonymy given by Weber and Beaufort.

Rasbora philippina Günther.

Rasbora philippina GÜNTHER, Challenger Exp., Zool. 1 Shore Fishes (1880) 58.

Dorsal II, 7; anal III, 5; pectoral I, 13, 14; ventral I, 7; lateral line, 29, 30; transverse line, $\frac{4.5}{1}$; scales between nape and dorsal, 12; pharyngeal teeth, 5, 4, 1–1, 4, 5.

Body elongate, little elevated, the ventral profile more convex than the dorsal; top of head straight to nape, gently arched from there to dorsal fin; depth 3.3 to 3.8 in length, head 3.8 to 4; eye 2.5 to 3.2 in head, equal to or 1.3 in the nearly flat interorbital space; snout short, 1.2 to 1.25 in eye, 3.2 to 3.6 in head; mouth quite oblique, its upper end about level with upper border of pupil, its lower end not extending posteriorly to front border of eye, which however is reached by maxillary; lips thin, the upper one with a median notch into which the symphysial knob of the projecting lower jaw fits; origin of dorsal nearer to caudal than to tip of snout, much nearer origin of ventral than anal, opposite tenth or eleventh scale of lateral line, and a little behind ventral, which is behind ninth or opposite tenth scale; distal margin of dorsal slightly convex, its height 0.75 to 0.8 that of length of head; margin of anal concave, its height a trifle more or less than 0.75 of dorsal; pectorals 1.2 to 1.33 in head, their tips not reaching ventrals; ventrals 1.45 in head, not reaching anus, their origin nearer to anal than to operculum; caudal longer than head, the longest rays more than twice as long as the shortest rays; length of caudal peduncle $1\frac{1}{8}$ to 1.4 in head, its least depth $1\frac{4}{9}$ to $1\frac{7}{9}$ in its length; nine rows of scales between the lateral lines counted over the back above anal fin, seven to nine rows counted over the middle of caudal peduncle; some specimens have the scales irregular and the midlateral row replaced by rows of very small scales.

Color in alcohol yellowish brown, back darker, and fading to yellowish white on throat and belly; top of snout blackish; a narrow dark brown stripe from nape to dorsal; a broad dark brown band from shoulder to caudal, often with a central black line, above which may be a pale streak; either or both may be lacking; in scales on sides outlined by broad dark marginal bands or rows of dots; a brown streak along base of anal and rows of brown dots on ventral margin of caudal peduncle; fin rays more or less dusky dotted or colorless.

Here described from thirty-six specimens, 53 to 72 millimeters in length, obtained by me in Titunod River, near Kolambugan, Lanao Province, Mindanao. The largest specimens were mature.

I make this disposition of my material with reluctance, as it disagrees with Günther's unsatisfactory diagnosis in several particulars. Günther's specimens had the lateral line 28–29; the origin of the dorsal fin opposite the ninth and tenth scales of the lateral line; the head $4\frac{1}{3}$ times in the length; and the pectoral fin as long as the head. However, it is not probable that my material is more than a geographical race of *R. philippina.*

From *R. argyrotaenia,* as defined by Weber and Beaufort, it differs in proportions of head, depth, eye, interorbital, caudal peduncle, position of dorsal, longer maxillary, and other minor particulars. A large series of specimens from many localities might show the identity of *R. philippina* with *R. argyrotaenia,* but for the present at least they must be considered specifically distinct.

Previously known only from the vicinity of Zamboanga, Mindanao, where it was collected by the Challenger Expedition about 1875, and by Seale in 1908.

In the Bureau of Science collection are six specimens of *Rasbora,* collected in Cagayan River at Cagayan de Misamis, Misamis Province, Mindanao, by Mr. Seale. The specimens, which vary from 30 to 65 millimeters in length, are in wretched condition and badly mutilated, but they probably belong here.

CYPRININÆ

Body oval or more or less elongate, head and body more or less compressed or sometimes depressed, belly not trenchant, rounded, or even flattened in which case the pectorals and ventrals are horizontal; the dorsal may be long or short with from seven to thirty branched rays, and with or without an osseous spine which may be smooth to strongly serrate behind; origin of dorsal before, opposite, or rarely slightly behind that of ventrals; anal short, branched rays five to nine, an osseous spine usually lacking; when present it may be serrated; pectorals and ventrals always well developed; caudal fin forked or emarginate; mouth terminal, inferior, or subinferior, generally small, always protractile; the jaws may have a soft or a horny covering or the lower jaw may have a sharp bony edge; a symphysial knob fitting into a notch on upper jaw is never present; lips may be present or absent; the lower lip may be separated from skin of isthmus by a complete postlabial groove, which is continuous around corner of mouth, or it may be interrupted in the middle, with a separate groove behind each lateral half; scales small to large, with the lateral line running along middle of side of tail in Philippine species; pharyngeal teeth nearly always in three series, rarely in two or in a single row.

This group includes the only members of the Cyprinidæ of commercial or economic importance, and most of the Philippine species belong here.

Key to the Philippine genera of Cyprininæ.

a^1. Anal spine serrated behind........ **Cyprinus.**
a^2. Anal spine not serrated behind.
  b^1. Lower jaw spatulate, curved upward, its tip meeting top of snout. **Mandibularca.**
  b^2. Lower jaw not spatulate, with more or less fleshy lip, not curved in a segment of a circle.
    c^1. Mouth terminal, oblique, its posterior margin reaching beyond front margin of eye; two maxillary barbels........ **Hampala.**
    c^2. Mouth terminal or subinferior, not extending beyond front margin of eye; four barbels in our species.
      d^1. Postlabial groove not interrupted in the middle behind chin and continuous around corner of mouth........ **Cephalakompsus.**

*d*². Postlabial groove interrupted in middle behind chin but continuous around corner of mouth.
  *e*¹. Lower jaw truncate, reaching but halfway to end of arch of upper jaw .... **Ospatulus.**
  *e*². Lower jaw not truncate .... **Barbodes.**

Genus **CYPRINUS** Linnæus

Cyprinus LINNÆUS, Syst. Nat. ed. 10 1 (1758) 320.

Mouth moderate, terminal, barbels long, four; dorsal very long, its origin opposite to that of ventrals, the last spine bony, stout, and serrated behind; anal short, its origin below posterior half of dorsal, its third spine strongly ossified and serrated behind; scales large, the lateral line complete, running in the middle of tail; gill openings wide, reaching to below hind border of preoperculum, gill membranes broadly attached to the isthmus; pharyngeal teeth, 3, 1, 1–1, 1, 3, broad, truncate, molarlike, with the crown furrowed, flat, or somewhat hollowed.

Large fishes of the fresh waters of Asia and introduced into various parts of the world as food fishes.

Cyprinus carpio Linnæus. Carp.

Cyprinus carpio LINNÆUS, Syst. Nat. ed. 10 1 (1758) 320; GÜNTHER, Cat. Fishes Brit. Mus. 7 (1868) 25.

Dorsal III, 17–22; anal III, 5; pectoral I, 15; ventral I, 7–9; lateral line, 34–40; transverse series, $\frac{5}{5}$.

The body is stout, more or less compressed, heavy anteriorly, color silvery, greenish or gray, without spots or markings. This species, which is a native of China, has been cultivated for many centuries. Consequently there are a great many varieties, with extraordinary differences in form, proportions, squamation, development of fins, and color. Under favorable conditions it attains a length of nearly 1.5 meters and a weight of over 20 kilograms.

Taken to Europe in the twelfth and thirteenth centuries, it is now found in fresh waters all over Europe and the United States; by the Chinese it has been carried to Japan, Hawaii, Java, Sumatra, and other parts of the Orient. Singularly enough, though the Chinese have been coming to the Philippines for more than a thousand years, they do not seem to have established carp here.

In 1915 two thousand carp fry were brought from Hongkong to Manila at the suggestion of Mr. Alvin Seale. A few were kept in a pond on the grounds of the Bureau of Science, but most of them were placed in a pond belonging to Dato Piang, at Dulauan, Cotabato Province, Mindanao. A few months later when the Rio Grande de Mindanao was in flood the fish escaped and they are now established in the Pulangi and its tributaries between Dulauan and Fort Pikit.

In 1916 Governor Coverston of Lanao planted fifty-nine carp fry in Lake Dapao and twenty-one in Lake Nunuñgan. Nothing is known definitely of those placed in Lake Dapao, but those in Lake Nunuñgan survived and carp are now becoming fairly numerous. In a few more years, fish may be taken from this lake and used to stock the other lakes of the Lanao Plateau.

Carp were taken from Manila and planted in various crater lakes in Luzon, but as there were neither breeding nor feeding grounds for them in those places they perished without reproducing.

While carp are not a first-class food fish, they are much better than anything available in many regions away from the sea. Their introduction into certain rivers of Luzon and Mindanao, if not in some other islands, would be a benefit to the inhabitants in that they would furnish an abundance of cheap food.

Genus **MANDIBULARCA** novum

The somewhat oblong, rather deep body is more or less compressed, strongly so posteriorly, with a broad, rounded ventral surface; the short, broad, blunt snout is without pores or tubercles; the rather small, terminal, slightly oblique mouth has a short protractile upper lip and a thin, elongated, curved, spatula-shaped lower jaw which extends upward around mouth to upper profile of snout; upper lip relatively wide and curtain-like, but lower lip thin and usually altogether absent on tip of mandible; the eyes have a thin, narrow, circular false lid composed of a fold of the outer covering of the eyeball; both rostral and maxillary barbels present; dorsal begins in advance of ventrals, and has a scaly basal sheath; dorsal has four spines, the last one jointed but not serrated, and eight rays; anal has five rays; scales rather large, with longitudinally radiating lines; the lateral line is complete, with simple tubes, and extends down middle of caudal peduncle; gill membranes united to isthmus opposite preoperculum; gill rakers short, seven to fifteen; no pseudobranchiæ; pharyngeal teeth, 5, 3, 2.

This genus is distinguished at once by the elongated, upward-curved and peculiarly shaped lower jaw, from which it is named.

The only species known is found in the Lanao Plateau of Mindanao.

Mandibularca resinus[2] sp. nov. Bagan̄gan.

Dorsal IV, 8; anal III, 5; ventral I, 8; lateral line, 27 or 28; transverse series, $\frac{4.5}{3.5}$.

The robust body is laterally compressed, especially the posterior half and particularly the caudal peduncle; depth from 3 to $3\frac{1}{3}$ times in length, and head from 3.7 to 4.1 times; back very strongly arched from head to origin of dorsal; sometimes the curve is uniform from tip of snout, but usually it increases markedly at nape; eyes high up, of medium size, 4 to 4.75 times in head and $1\frac{1}{8}$ to 1.4 times in the short, broad, blunt snout; interorbital space wide and flat or nearly so, 1.7 times to twice diameter of eye; mouth terminal, upper lip short and protractile, margined by a relatively wide flap, which continues on to lower jaw but not to its tip; the projecting mandible is drawn out to a narrow, concave, upward-curving, fleshless, more or less spatula-shaped beak; the wide lower part fits over mouth when closed, while the narrower upper part curves over into the space between the premaxillaries and its tip extends almost to or flush with upper profile of snout; the mouth extends less than halfway from tip of snout to eye; a maxillary barbel is behind corner of mouth, a rostral barbel about halfway between it and top of snout; both barbels are of nearly the same size, and vary in length from the diameter of an eye to three-fourths of that length; origin of dorsal opposite eighth scale of lateral line, origin of ventrals behind eighth or opposite ninth; first dorsal spine very small; fourth basally stout, without serrations, and a little more or less than 0.7 the length of head; anal lower than dorsal; ventrals do not reach anus; the pectorals are much shorter than head and do not reach ventrals by two scales; caudal deeply incised, with pointed lobes, and nearly or quite as long as head; there are twelve scales around the much-flattened caudal peduncle, its depth from 2 to 2.3 times in head.

In life the color above is dark olive green, with concolorous dorsal and caudal fins; this merges on sides to an almost golden yellow or the sides are brassy, with the outline of each scale more or less dusky; a vertical dark bar or crescent is more or less evident at base of each scale; belly white; lower half and underside of head often nearly golden yellow; pectorals, ventrals, and anal pale yellow, with more or less hyaline tips.

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[2] *Resinus*, turned upward.

In alcohol the color is duller, shading from dark green above to golden yellow or whitish below, with a silvery sheen over all; top of snout blackish green; caudal dusky with hyaline tips; the other fins all more or less suffused with yellow or red, with hyaline tips; specimens in alcohol for fifteen years are light brownish to whitish beneath, with a silvery sheen.

On September 11, 1922, I collected seven specimens of this unique fish in the rapids of the Agus, just below Dansalan bridge a short distance from Lake Lanao; three of these were females, nearly ready to spawn. They varied in length from 133 to 176 millimeters; the largest one measured 220 millimeters with the caudal fin. In the collection of the Bureau of Science are three specimens obtained by Chaplain Joseph Clemens in June, 1907, at "Lake Lanao," varying in length from 164 to 178 millimeters. As they were bought in the market it is not possible to say whether they were actually caught in the lake or not.

As far as I know, fishes of this species occur only in the boiling outlet of Lake Lanao, where the Moros catch them with hook and line, but in all probability they also occur in the lake itself. The name *bagañgan* is applied by the Moros to any large, greenish, more or less brassy or golden cyprinid. I therefore look with doubt on the Moro statement that this fish is found in Lake Uyaan.

Genus **HAMPALA** Bleeker

Hampala BLEEKER, Nat. Tijdschr. Ned. Ind. 20 (1859-60) 430.

Body elongate, compressed, with pointed snout; the wide, oblique, terminal mouth extends posteriorly beyond front margin of orbit; upper lip broadened anteriorly, lower one laterally; a postlabial groove parallel with lips but interrupted in middle of lower lip; a barbel behind corner of mouth; dorsal with eight branched rays and a low basal scaly sheath, its origin opposite that of ventrals, its third hard spine feeble and finely serrated; anal with five branched rays; scales large, radiately striate or granulated, sometimes with reticulated lines; lateral line complete, slightly curved ventrally, the tubes simple; gill membranes united to isthmus opposite posterior part of eye; pharyngeal teeth spoon-shaped, 5, 3, 1-1, 3, 5.

Found in fresh water from Borneo to Indo-China and Siam.

Hampala lopezi sp. nov.

Dorsal III, 8; anal III, 5; pectoral I, 14; ventral I, 8; lateral line, 25; transverse line, $\frac{4.\ 5}{2\text{–}2.5}$; scales from nape to dorsal, 10; scales between lateral line and base of ventral, 2.5; scales on caudal peduncle, 12; pharyngeal teeth, 5, 3, 1–1, 3, 5.

Dorsal profile of the elongate, compressed body moderately convex; ventral profile uniformly convex from snout to tail; depth 3.4 in length, head 3; eye from 4 to 4⅔ in head and 1.3 in the blunt snout, which is from 3 to 3.5 times in head and equals the broad flat interorbital space; mouth terminal, very slightly oblique, extending backward just beyond a vertical through front margin of eye; a maxillary barbel behind corner of mouth and nearly or quite equal to eye; upper lip strongly protractile; origin of dorsal behind eighth scale of lateral line and opposite that of ventral; dorsal concave, its third spine slender, weak, and feebly serrate, its height about equal to distance from tip of snout to posterior margin of preopercle, or 1.47 in head; the hard part about 1.7 in total length of spine; pectorals small, their tips not reaching ventral base by width of two scales; ventral not reaching anus by width of one scale; axillary scale of ventral pointed, a third longer than eye; length of caudal peduncle 1.64 to 2 in head, its least depth 1.2 to 1.4 in its length and 2.45 to 2.54 in head; caudal deeply forked, with long pointed lobes; scales with longitudinally radiating lines; pharyngeal teeth small, with curved points, the grinding shoulder comparatively wide.

Color in alcohol silver gray to brownish on sides, the dorsal surface very dark, tip of snout black; paler below, becoming white on belly, and with yellowish glints under head and tail; a broad black band from shoulder to caudal; a dark silver or lead-colored band passing downward from around base of dorsal and connecting with lateral band; a narrow black stripe along upper and lower margins of caudal; rest of fins yellowish or hyaline.

Here described from the type, No. 9186, Bureau of Science collection, and three cotypes, varying in length from 55 to 85 millimeters. They were obtained at Langbuan, Busuanga, by G. A. Lopez, collector of the Bureau of Science, for whom I take pleasure in naming this species. In the two smaller specimens the mouth does not extend back beyond front margin of eye, but this character evidently develops with age, at least in this species.

Genus **CEPHALAKOMPSUS**[3] novum

Body oblong, elongate, laterally compressed, with rounded abdomen; head broad, much longer than depth of body, with a stout, clumsy, prominent snout; interorbital space broad, concave, top of snout with a median and two lateral bony protuberances; mouth short but large, subinferior, somewhat horseshoe-shaped, extending about halfway to eye; upper lip strongly protractile, lower lip and jaw included; both lips thick, rugose, with a continuous postlabial groove parallel with lips, passing around corners of mouth and across chin; a pair of rostral and maxillary barbels; preorbital triangular, its point directed forward, suborbital very narrow; the eyes have a very narrow gelatinous rim or lid; dorsal with eight branched rays and a basal scaly sheath, its origin in advance of that of ventrals, its fourth spine rather slender and feebly denticulated; anal with five branched rays; scales rather large, with concentric striæ; lateral line complete, descending strongly to below origin of dorsal, then curving upward to a point above anal fin, thence running along middle of caudal peduncle, the sensory tubes simple; gill membranes united to isthmus opposite middle of eye; pharyngeal teeth, 5, 3, 2–1, 2, 4, with pointed, irregular, hooked tips.

This genus is distinguished from related genera by the uninterrupted groove behind lower lip, continuous across chin as well as around corner of mouth, by the lack of sensory folds on head, the rather weak and feebly denticulated dorsal spine, and the large and clumsy head and snout.

The distribution is that of the single species known.

Cephalakompsus pachycheilus[4] sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 14; ventral I, 8; lateral line, 26; transverse line, $\frac{4.5}{3.5}$; scales around caudal peduncle, 11; scales between nape and dorsal, 11.

The elongate oblong body laterally compressed, especially on posterior half, its depth 3.86 times in length; the large head a third longer than depth and contained 2.87 times in length; eye high up, posterior margin midway between tip of snout and posterior extremity of head; it is contained 5.2 times in the latter and 1.73 times in the broad, irregular, clumsy snout, the last named 2.23 times in head; the broad, concave interorbital space nearly 1.5 times eye diameter; the subterminal, curved, subinferior mouth reaches about halfway to eye; the broad, thick, fleshy upper lip strongly protractile and the lower jaw is included, with a continuous groove behind thick lower lip; the stout rostral barbels are a little longer than eye, while the still thicker maxillary barbels are a third longer than eye; the upper profile concave from the bony hump on top of snout to nape, and gently convex from there to beyond dorsal; lower profile strongly convex from chin to caudal peduncle; origin of dorsal opposite posterior part of eighth scale in lateral line, that of ventral opposite ninth scale; fourth dorsal spine rather slender, with weakly serrate posterior margin, and a trifle more than half the length of head, its bony part about 2.8 times in head; pectorals short, extending not quite $\frac{3}{4}$ the distance to ventrals, which equal pectorals in length, their tips separated by the width of one scale from anus; anal low, its height hardly more than $\frac{3}{5}$ that of dorsal; the least height of caudal peduncle contained 1.5 times in its length and 3.25 times in head; caudal deeply forked, with pointed lobes, its length a trifle more than 5 times in that of head and trunk; snout with small epidermal nodules and raised spots.

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[3] ΚεΦαλή, head; *ἄκομψος*, uncouth.

[4] Παχυs, thick; *χεῖλος*, lip.

Color in alcohol nearly uniform brownish yellow, darker dorsally, with indications of a dark band from nape to dorsal fin; snout and interorbital space darkest; all fins pale, dorsal spine and rays slightly dusky.

Here described from the type and only specimen, a spawning female 112 millimeters long, or 134 millimeters over all, collected by me at Dansalan, Lake Lanao, Mindanao, May 5, 1921.

Genus **OSPATULUS**[5] novum

Body thick, robust, with rounded abdomen, and with the isthmus and underside of head very broad; the rather large subinferior mouth apparently cannot be closed, the truncate lower jaw seemingly having its anterior end cut off so that it reaches but halfway to the extremity of the arch of upper jaw; the thick lower lip laterally produced in a wide flap on each side, thus forming two pocketlike recesses on underside; postlabial groove parallel to lips and continuous around corners of mouth but interrupted at chin; upper lip strongly protractile, lower jaw included; both rostral and maxillary barbels present; interorbital space broad, profile back to nuchal hump nearly straight; dorsal without a basal scaly sheath, or with it feebly developed, its origin in advance of ventral, its longest spine slender and feebly denticulated; lateral line complete, little curved, with simple tubules; gill membranes attached immediately behind posterior extremity of eye; scales rather large with both longitudinally radiating and concentric striæ.

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[5] *Os*, mouth; *patulus*, standing open.

This genus is strongly differentiated by the shape of its lower jaw, lip, and mouth. It is known only from Lake Lanao, Mindanao.

Key to the Philippine species of Ospatulus.

a^1. Dorsal spines III; scales on caudal peduncle, twelve; head 3.6 in length .... **O. truncatulus.**

a^2. Dorsal spines IV; scales on caudal peduncle, ten; head 2.7 in length. **O. palaemophagus.**

Ospatulus truncatulus[6] sp. nov.

Dorsal III, 8; anal III, 5; pectoral I, 13; ventral I, 8; lateral line, 26; transverse line, $\frac{4.5}{3}$; scales on caudal peduncle, 12; scales between nape and dorsal, 11; pharyngeal teeth, 4, 2, 2–2, 2, 4.

Body thick and robust, upper profile marked by a very decided hump behind nape, after which there is a very slight upward curve to dorsal; depth contained 3.17 times in length and greater than the short, rather blunt head, which is contained 3.6 times in length; top of head wide, nearly flat, sloping in a nearly straight line from tip of snout to nape; eyes very high, 4.28 times in head and 1.5 times in snout; interorbital space greater than the blunt snout, which is contained 2.85 times in head; mouth terminal but apparently inferior, oblique, upper jaw strongly protractile, with upper lip of medium thickness, much broader at corners of mouth than at middle of lip; mouth seems to be open even when closed, as the truncate lower jaw is very short, extending but halfway from angle of the two jaws to anterior extremity of mouth; two broad fleshy flaps form lateral pockets on underside of lower lip; the slender rostral barbels more than an eye diameter in length; the stouter maxillary barbels more than one and a half times an eye diameter; origin of dorsal opposite ninth scale; the slender third dorsal spine two-thirds the length of head, and half again as long as the minutely serrated bony part; pectoral less than 0.8 the distance to ventral and fails to reach latter by the width of two scales; origin of ventral opposite tenth scale of lateral line, from which it is separated by 3.5 scales; ventrals are

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[6] *Truncatulus*, from the truncate form of the lower jaw.

$^{9}/_{11}$ the length of pectoral and lack half a scale of reaching anus; anal low, its height a trifle more than the hard part of dorsal spine and more than twice in head; caudal peduncle rather long, its least depth 2.5 times in its length, which is two-thirds that of head; caudal fin deeply forked, with pointed lobes, and equals head in length; lateral line slightly curved, but does not ascend to middle of side until fifth scale from posterior end; pharyngeal teeth more or less crooked, only one in outer row large, and with some but partially developed.

General color in alcohol yellowish brown, dusky on dorsal half, much paler below; top of head and region in front of dorsal darkest; fins all pale, except dorsal which is slightly dusky.

The type of the species and genus is a ripe male, Bureau of Science collection No. 9190, which I obtained at Dansalan, Lake Lanao, in May, 1921. It was with *Barbodes katolo,* which it resembles in general outline.

Ospatulus palaemophagus[7] sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 14; ventral I, 8; lateral line, 26; transverse line, $\frac{4.5}{2.5}$; scales on caudal peduncle, 10; scales between nape and dorsal, 10; pharyngeal teeth, 4, 3, 2–2, 3, 4.

The stout oblong body laterally compressed, its depth 3.38 times in length; head very large and contained 2.7 times in length, the opercular flap extending beyond base of pectorals; top of head nearly flat and horizontal; dorsal profile with a nuchal hump of moderate height, followed by a low flat curve; ventral profile much more strongly convex; interorbital space contained 1.3 times in the blunt snout, which is one-third the length of head; a prominent bump on upper surface of anterior end of snout; eye high, and contained 4.75 times in head and $1\frac{2}{3}$ times in snout; mouth large, terminal, slightly oblique, lower jaw included, with protractile and rather thin upper lip; lower jaw much as in *O. truncatulus* but with the lip and flaps beneath it thinner; rostral barbels a little shorter than an eye diameter, maxillary barbels a fourth longer than an eye diameter, all the barbels approximately equal in thickness; origin of dorsal opposite seventh lateral-line scale, that of ventral opposite eighth scale; the moderately stout dorsal spine a trifle more than half the length of head, and nearly half again as long as the feebly serrate hard part; length of pectoral 0.8 the distance to base of ventral, and reaches within 1.5 scales of latter; origin of ventral separated by 2.5 scales from lateral line; ventrals four-fifths as long as pectorals and fail to reach anus by the width of two scales; anal low, its height a little more than the hard part of fourth dorsal spine; caudal peduncle rather short, its depth 3.16 times in head and 0.75 of its length, which is 0.42 of head; caudal fin forked, lobes wide, and a trifle more than 0.7 as long as head; lateral line gently curved until sixth scale from posterior end, when it proceeds along middle of side.

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[7] Πᾰλαῐμῳν, Palaemon, a sea god, and the name of a genus of shrimps; Φαγος, eating.

Color in alcohol dark yellowish brown, becoming blackish on top of head and snout and blackish brown along dorsal region; a dark opercular spot; fins all pale except dorsal, which has the spines and rays darker.

Here described from the type and only specimen, No. 9200, Bureau of Science collection, a male 105 millimeters long, with a length over all of 128 millimeters, collected by me at Lumbatan, a town on the south shore of Lake Lanao. It was mixed with a number of other cyprinids of the same general outline and color. In the mouth and throat was a fresh-water shrimp, *Palaemon* sp., which it had evidently been in the act of swallowing when captured.

Genus **BARBODES** Bleeker

Barbodes BLEEKER, Conspectus Systematis Cyprinorum, Nat. Tijdschr. Ned. Ind. **20** (1859) 431.

Body oblong elongate, compressed, with short and usually blunt snout; minute pores present on top of snout and head in some of our species; pearly epidermal spots or tubercles often present during the breeding season; mouth terminal or somewhat inferior and more or less oblique, with a more or less protractile upper jaw; lips smooth and generally thin, with a postlabial groove which is interrupted in middle of lower jaw behind chin; a rostral and a maxillary pair of barbels always present; dorsal with seven to nine branched rays and three or four spines and a more or less developed scaly sheath at its base; last dorsal spine enlarged, most of its length bony, and nearly smooth to very strongly serrate behind; anal with five to seven branched rays and three weak spines; scales large to medium in size, smooth and cycloid, or with longitudinally radiating and often much-branched lines, or both; lateral line complete, more or less curved downward, running along middle of caudal peduncle, at least posteriorly, the sensory tubes simple; gill membranes united to isthmus opposite preopercle or hind part of eye; pharyngeal teeth, 5 or 4, 4 or 3, 3, 2, or 1–1, 2, or 3, 3 or 4, 4 or 5.

Generally distributed in southeastern Asia and from Borneo to the Philippines, with one widespread species occurring as far eastward as Lomok.

Key to the Philippine species of Barbodes.

a^1. Eight scales from nape to dorsal.

  b^1. Dorsal spines III; scales on caudal peduncle thirteen or fourteen; axillary scale equal to or one-seventh more than eye.. **B. hemictenus.**

  b^2. Dorsal spines IV.

    c^1. Scales on caudal peduncle twelve; axillary scale 1.5 times to twice eye .... **B. ivis.**

    c^2. Scales on caudal peduncle eleven, rarely twelve; axillary scale much less than eye.......... **B. tumba.**

a^2. Eight to nine scales from nape to dorsal.

  d^1. Four large dark spots, often with dark bar along middle of side; usually dark spot at base of dorsal and often at base of anal; dorsal spines IV.

    e^1. Thirteen to fourteen scales on caudal peduncle. **B. quinquemaculatus.**

    e^2. Twelve scales on caudal peduncle.

      f^1. Head 3.4 to 3.8 in length; transverse series scales $\frac{4.5}{2.5\text{–}3}$; dorsal spine serrate.......... **B. binotatus.**

      f^2. Head 4.5 in length; transverse series scales $\frac{5}{2.5}$; dorsal spine smooth.......... **B. montanoi.**

  d^2. No dark spots or band on side; dorsal spines III; scales on caudal peduncle eleven.......... **B. clemensi.**

a^3. Nine scales from nape to dorsal.

  g^1. Eleven scales on caudal peduncle.

    h^1. Twenty-two to twenty-four scales in lateral line, rarely twenty-five or twenty-six; dorsal spines IV; a dark silver band from shoulder to caudal.......... **B. amara.**

    h^2. Twenty-four to twenty-nine scales in lateral line; no spots or dark band on sides; dorsal spines III.......... **B. flavifuscus.**

  g^2. Twelve to thirteen scales on caudal peduncle; twenty-seven to twenty-eight scales in lateral line; four large dark spots and broad dark bar on side.......... **B. manguaoensis.**

a^4. Nine to ten scales from nape to dorsal.

  i^1. Twenty-four to twenty-six scales in lateral line; four large dark spots and dark bar along side; dark spot at base of dorsal. **B. bantolensis.**

  i^2. Twenty-eight scales in lateral line; no dark spots or bar on side. **B. lanaoensis.**

a^5. Eleven scales from nape to dorsal.

- j^1. Scales on caudal peduncle eleven; transverse series $\frac{4.5}{3}$.... **B. katolo.**
- j^2. Scales on caudal peduncle thirteen; transverse series $\frac{6}{4}$ .. **B. manalak.**

a^6. Eleven to fifteen scales from nape to dorsal.

- k^1. Dorsal spines III; dark stripe from shoulder to caudal; head not laterally compressed beneath.. **B. lindog.**
- k^2. Dorsal spines IV; no dark stripe on side; ventral half of head strongly compressed laterally.. **B. palata.**

Barbodes hemictenus Jordan and Richardson.

Barbodes hemictenus JORDAN and RICHARDSON, Bull. U. S. Bur. Fisheries 27 (1907) 241, fig. 5.

Dorsal III, 8; anal III, 5; pectoral I, 15; ventral I, 8; lateral line, 24, 25, or 26; transverse line, $\frac{4.5}{2.5}$ or $\frac{4.5}{3}$; scales from nape to dorsal, 8, rarely 9; scales on caudal peduncle, 13 or 14; scales between origin of ventral and lateral line, 2.5; pharyngeal teeth, 2, 3, 4 or 5–5 or 4, 3, 2, their tips slightly hooked.

The relatively full, rounded oblong body differs in form from that of all closely related species, being proportionately thicker and less compressed, only the caudal peduncle being much flattened; predorsal region elevated, but lacking the rather sharp median ridge of *B. tumba;* dorsal profile uniformly and moderately convex from tip of snout to origin of dorsal; abdomen noticeably full and rounded; depth from 2.75 to 3.1 times in length; head narrower than trunk, rather small, its length 3 to 3.8 times in length and about 1$\frac{1}{3}$ times in depth of trunk; the eyes have a narrow circular gelatinous lid, are high up, 3.14 to 3.7 in head and 1.3 to 1.7 in the broad, gently rounded interorbital space; the short rounded snout equals eye in length or is a seventh longer; mouth rather small, slightly oblique, upper lip protractile, lower jaw included, lips as in *B. tumba;* the short maxillary scarcely extends posteriorly to eye; barbels of moderate thickness, rostral extending to pupil of eye or beyond, maxillary nearly to or even beyond posterior margin of preopercle; origin of dorsal opposite posterior part of or behind eighth scale of lateral line; it is usually nearer base of caudal than tip of snout and is opposite or slightly behind origin of ventral; third dorsal spine slender or of moderate strength, its length equal to or 1.2 in that of head; its hard part weakly serrate along its upper half, 0.8 or more than 0.8 as long as the entire spine and approximately equal to height of anal;

pectorals broad and relatively short, 1.3 in head, their tips not reaching base of ventrals by the breadth of a scale; ventrals short, 1.5 in head, not reaching anus by the width of one or two scales; ventral axillary scale pointed, its length equaling that of snout; caudal peduncle short, its length 1.5 to 1.75 times in head, its least depth 0.8 to more than 0.9 its length; caudal fin broadly and deeply forked; in a few cases there are nine scales before dorsal; in one specimen, 90 millimeters long, there were but twelve scales on the caudal peduncle; with a lens the top of the head is seen to be covered usually with minute pores.

Color in alcohol of dorsal region and top of head blackish, merging to dark olive brown on sides, underparts paler or yellowish; a broad black band extends from shoulder to base of caudal peduncle; a large, more or less circular black spot on middle of side of caudal peduncle, just before caudal fin; a more or less evident blackish blotch on each side of forward part of dorsal fin base; a line of minute specks forms a dark margin to scales on sides; fin rays more or less faintly dusky. The markings are well shown in Jordan and Richardson's excellent figure.

Here described from one hundred twenty-two specimens collected by Prof. A. L. Day, in Sabaan River, near Lake Naujan, Mindoro. They range in size from 25 to 100 millimeters, and all agree in essential characters and color, the latter being different at all stages from that of other species of the same size. Eleven specimens, varying from 76 to 100 millimeters in length, were females which were ready to spawn or which had already spawned. Males in spawning condition and specimens without any visible development of the sexual organs all had the same characteristic form of the abdomen.

I have also examined six specimens, from 46 to 72 millimeters in length, collected by A. L. Day from Mamboc River, a tributary of Lake Naujan, Mindoro.

The distinct species, originally described from Baco River, on the north coast of Mindoro, is thus far known only from the northeastern part of this little-explored island.

Barbodes ivis (Seale).

Barbus ivis SEALE, Philip. Journ. Sci. § A 4 (1909) 494, pl. 1.

Dorsal IV, 8; anal III, 5; pectoral I, 15; ventral I, 7; lateral line, 23 to 25, usually 24; transverse line, $\frac{4.5}{3}$; scales from nape to dorsal, 8; scales on caudal peduncle, 12; scales between base of ventral and lateral line, 2.5; pharyngeal teeth, 5, 3, 2, or 3, 5, 3, 2–2, 3, 5, 3, or 2, 3, 5.

Body much elevated, laterally compressed, tapering toward the wedgelike dorsal side, caudal peduncle very wide and much compressed laterally; dorsal profile nearly straight from tip of snout to dorsal fin, or more or less convex, with a small hump at nape; depth 2.1 to 2.6 in length; head small, pointed, 3.5 to 3.8, its depth about 1.5 times in its length; eye 3.6 to 4 in head, 1.5 to 1.6 in the broad, flat, or nearly flat interorbital space; snout broad, rather pointed, with blunt rounded tip, equal to or a fifth longer than eye; mouth small, subterminal, slightly oblique with included lower jaw, posterior extremity of maxillary beneath nostrils; lips rather thin, upper lip strongly protractile; barbels rather slender, long, the upper extending to anterior margin or to center of eye, the lower sometimes beyond posterior margin of preopercle; origin of dorsal behind eighth or opposite to or behind ninth scale of lateral line, that of ventral behind seventh or opposite eighth scale; fourth dorsal spine stout, its height equal to or more than three-fourths the length of head; the hard part is noticeably and rather strongly serrate except on its basal portion, its height a little more or less than four-fifths of dorsal; pectorals $1\frac{1}{4}$ to $1\frac{1}{3}$ in head, their tips failing to reach ventrals by the breadth of a scale or more; ventrals variable, 1.2 to 1.6 in head, their tips extending beyond anus or failing to reach it by the breadth of a scale; the long, sharp-pointed ventral axillary scale from one and a half times to nearly twice eye; the width of the broad flat caudal peduncle usually equal to its length or may be contained in it 1.25 times, its length contained from 1.3 to 1.6 in head; caudal deeply and broadly notched, upper lobe narrower; scales with longitudinally radiating lines.

Color in alcohol silvery gray, or in specimens many years in preservative silvery brown; dark or dusky above, paler on sides and becoming white on abdomen; a dark spot on nape; a large circular blackish spot on side of caudal peduncle, in advance of caudal fin; traces of one or two dark spots along median lateral line and one below anterior part of base of dorsal; lower side of caudal peduncle more or less yellow, the color extending upward across caudal peduncle behind the black caudal spot; traces of a broad dark silver bar more or less evident from shoulder to caudal spot; fins all colorless, rays more or less dusky, or in young specimens tips of dorsal, anal, and caudal dusky to black. In some specimens the scales of dorsal half have traces of a bluish or violet reflection.

Here described from the type specimen, 100 millimeters long, collected by Seale at Balabac; from a specimen, 96 millimeters long, collected by Seale at Paracan, Palawan; and from five specimens, 91 to 110 millimeters long, collected at Concepcion, Busuanga Island, by G. A. Lopez, in 1922. I have also examined three specimens, from 68 to 77 millimeters in length, collected at Langbuan, Busuanga Island, and eighteen specimens, 35 to 68 millimeters long, from Concepcion, Busuanga Island, all obtained by Lopez in September, 1922. I have also seen eighty-nine cotypes, 33 to 96 millimeters in length, collected by Seale at Balabac, and four specimens, 56 to 70 millimeters in length, collected by Seale at Malampaya Sound, Palawan.

This species is distinct in appearance and readily separable at all stages from any other Philippine species. Thus far it is known only from Balabac, Palawan, and Busuanga.

Barbodes tumba[8] sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 15 or 14; ventral I, 7; lateral line, 24 to 26; transverse line, $\frac{4.5}{2.5}$ or $\frac{4.5}{2}$; scales from nape to dorsal, 8; scales on caudal peduncle, 11, or 12 on small specimens; scales between origin of ventral and lateral line, 2 or 2.5.

The deep robust body elevated dorsally, with a more or less evident sharp median ridge from nape to dorsal, head and anterior part thick and heavy, with rounded abdomen and posterior half strongly compressed laterally; depth from 2.5 to 3.6 times in length, the broad blunt head from 2.8 to 3.75 times; a circular gelatinous lid to the eyes, which are high up, their posterior margin midway between tip of snout and posterior margin of operculum, or in the anterior portion of head; eyes 3.5 to 4.5 in head and 1.4 to 1.8 times in the broad, flat, or gently rounded interorbital space; snout usually broadly rounded, rarely somewhat triangular, blunt, and equal to or occasionally a third longer than eye; the rather small mouth terminal, moderately oblique, lower jaw included; maxillary short, not extending posteriorly as far as margin of eye; upper lip thin, protractile; underside of lower lip has a broad but thin lateral fold on each side; there is no symphysial knob on underside of lower jaw; barbels usually stout and long, rostral extending from anterior portion to posterior margin of eye; the maxillary barbels may extend to posterior margin of preopercle or beyond; origin of dorsal midway of length or slightly anterior, and behind to seventh lateral-line scale; origin of ventral behind eighth, or sometimes opposite dorsal; fourth dorsal spine of medium stoutness or rather slender, weakly to moderately serrated, its height 1.3 to 1.75 in head; the hard part is from two-thirds to three-fourths of its total height; pectorals long, 1.3 to 1.5 in head, their tips separated by the breadth of one scale from or extending to base of ventrals; the latter from 1.5 to 1.85 in head and extending to within a scale or less than half a scale of anus; axillary ventral scale short, rounded, much less than eye in length; anal nearly as high as dorsal, extending over two-thirds or more of the length of caudal peduncle when depressed; length of caudal peduncle 1.4 to 1.8 in head, its least depth nearly equal to or 1.5 in its length and 1.7 to 2.4 in head; caudal fin broadly notched, its length a fourth or more of head and body; upper lobe usually narrower and more pointed; scales from nape to dorsal usually eight, sometimes seven, and in a few cases by the intercalation of small scales they number nine or ten; scales with conspicuous longitudinal branching lines; a row of pores continues from lateral line, passing forward above and around eye; with a lens the top of the head is seen to be covered with many minute pores; pharyngeal teeth, 5, 3, 2–2, 3, 5.

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[8] *Tumba* is a Marinao or Lanao Moro name for several species of Cyprinidæ.

The general color in life is dark greenish or olive above, paler on sides, and white or with a golden tinge on the underparts, a silvery luster over all; a dark lateral band and dark spots described below more or less evident.

The general color in alcohol is dark silvery; top of head and dorsal region very dark brown or blackish brown, becoming paler on sides and merging into white on chin and belly; sometimes sides of head and underparts are more or less golden; specimens from clear cold mountain streams often have the scales with a violet-blue luster; each scale usually with a dark vertical bar posteriorly; a dark or bluish black band from shoulder to caudal is more or less evident; a large blackish blotch near middle of side of caudal; a spot or bar on each side, below anterior part of dorsal; often there are two dark spots on middle of side below or behind dorsal; the rays of the lips are more or less darkened; fins more or less dusky; a large black spot is often present on nape; the whole body, except the underparts, is thickly sprinkled with minute dark specks. This species varies in color, scale counts, and proportions so that it is sometimes difficult to determine specimens satisfactorily. The dorsal profile may form a bold convex curve from tip of snout to dorsal, or the top of the head may be nearly straight, with an upward curve from nape to dorsal; the ventral profile is uniformly convex from chin to caudal peduncle.

Here described from thirty-nine specimens obtained in Siwagat River, a stream in the mountains east of Lake Lanao; one hundred seventy-six specimens from Lake Uyaan; forty-seven from Lake Nunuñgan; and thirty-four from the outlet of Lake Dapao. These specimens vary from 24 to 128 millimeters in length and were all collected in the highlands of Lanao Province, Mindanao, in September, 1922. None was in spawning condition, though some females 100 millimeters and upward in length had either spawned or else had the ovaries filled with immature eggs.

The distribution of this species is very interesting. Lake Uyaan is a small, oval, apparently crater lake, a few miles west of the southwest corner of Lake Lanao and several hundred feet higher in altitude. It has no apparent outlet, but is said to have an outlet in the bottom, the water emerging as a spring at Ganassi. Lake Nunuñgan lies about 24 kilometers southwest of Lake Lanao, and is entirely surrounded by lofty, nearly vertical mountains except on the northeast, where a creek flows into it. The lake is more than 1.5 kilometers in diameter, and a chain of hills lies across the place where one would expect to find a river flowing toward the sea; but there is a subterranean outlet at the foot of a great rocky hill, and one can see the tumba playing in and out of the cavernous passage into which the water flows on its way under the mountain, emerging on the other side four or five hours' travel distant. In both these lakes there are other fish; dalag, carried there by man beyond question, are not rare, and in Lake Nunuñgan carp planted in 1916 are now increasing rapidly. Now and then an eel is taken in Nunuñgan, and the Moros claim that *bagañgan,* a large cyprinid, occurs in Lake Uyaan, though this is doubtful.

Lake Dapao is several kilometers long, and was undoubtedly formed by the damming of a river valley. The outlet is a clear, cold, swift stream, in which tumba are exceedingly abundant, several hundred specimens having been obtained at a single shot. The lake lies several kilometers southwest of Ganassi, a town on Lake Lanao, at a somewhat lower altitude, and drains into Mataling River, which reaches the sea near Malabang, on the southern coast of Lanao Province. All of these lakes with outlets are cut off from the lowlands by waterfalls impassable to ordinary fish.

Siwagat River is a small, clear, cold stream with gravel bottom, in the mountains, about 19 kilometers east of Tamparan, a village on the eastern shore of Lake Lanao. No other fish ascends the river to this point, though at the foot of the mountains several species of fishes, cyprinids, eels, and dalag, occur.

From the closely related species, *Barbodes quinquemaculatus*, this species may be separated by the more anterior position of the dorsal, the broader, blunter snout, the fewer scales on the caudal peduncle, and the shorter, more-rounded ventral axillary scale.

Barbodes quinquemaculatus (Seale and Bean).

Barbus quinquemaculatus SEALE and BEAN, Proc. U. S. Nat. Mus. 33 (1907) 229, fig. 1.

Dorsal IV, 8; anal III, 5; pectoral I, 15; ventral I, 7, or sometimes 8; lateral line, 24, sometimes 25; transverse line, $\frac{4.5}{2.5}$ or $\frac{4.5}{3}$; scales from nape to dorsal, 8, rarely 9; scales on caudal peduncle usually, 13; scales between origin of ventral and lateral line, 2.5 or 3.

Body deep, moderately robust, predorsal region elevated, posterior half much compressed, preanal region deep and narrow; depth 2.6 to 2.9 in length, head 3.5 to 3.6; eyes from 3.8 to 4 times in head, and 1.5 to 1.6 times in the broad interorbital space, which is flat or nearly so, and is contained 2 to 2.5 times in head; snout rather narrow and pointed with broadly rounded tip, and as long as or an eighth longer than eyes; mouth terminal, oblique, lower jaw included, maxillary hardly extending to anterior margin of eye; barbels slender to moderately stout, rostral a fourth longer, maxillary barbel a half longer than eye, origin of dorsal opposite to or behind eighth scale of lateral line, and opposite to or behind origin of ventral, which is behind seventh or opposite eighth scale; fourth dorsal spine of moderate strength, its height 1.1 to 1.3 in length of head; the hard portion weakly to moderately serrate along its upper half, its height 1.3 to 1.4

in that of fin or 1.6 to 1.8 in head; pectorals very long, 1.1 to 1.25 in head, their tips reaching ventrals; ventrals also long, 1.2 to 1.35 in head, nearly or quite reaching anus, the pointed axillary ventral scale 1.5 times as long as eye; caudal peduncle wide and flat, its length 1.5 to 1.6 times in head, its least depth 1.1 to 1.25 times in its length; scales on caudal peduncle mostly thirteen, sometimes fourteen; pharyngeal teeth 5, 3, 2–2, 3, 5, their tips hooked; scales with longitudinally radiating lines.

Color in alcohol greenish, or more often pale brownish with a silvery luster, with dorsal region dark brown, becoming lighter on sides and pale on belly and throat; scales with more or less evident dark margins; a large dark spot on side near base of caudal; in a few small specimens there are two black spots on median lateral line, one below and one behind dorsal, a black blotch below base of dorsal and a dark streak at origin of lateral line; fins all pale or dorsal rays brownish.

Here described from seventeen specimens collected by Alvin Seale at the type locality, near Zamboanga, Mindanao, and varying from 52 to 122 millimeters in length. Seale and Bean say "D., 11; A., 7;" but this is evidently an error. Farther on they state "Second ray of dorsal ossified and strong," but second should be changed to fourth. Though small, the first and second spines are plainly evident.

In life the color is stated by Seale to have been—

> silvery with opalescent bronze reflections, scales above and on upper part of sides with greenish wash, more distinct on base of [dorsal?] fin; there is a slightly darker area at base of dorsal; head is bronzy greenish olive above; iris golden; a few specimens have the dusky area at base of dorsal forming a more or less distinct spot; a single black spot at base of caudal peduncle.

This species is very close to *B. binotatus,* from which however it differs in several details, particularly in shape, in the number of scales on the caudal peduncle, in the greater length of the ventral axillary scale, and in the feebler serration of the dorsal spine.

I have recently received six specimens from a stream flowing into Caldera Bay, near Zamboanga, which are from 50 to 97 millimeters in length; also eight specimens from Basilan, 56 to 100 millimeters long. The last named, preserved in formalin, are dusky above, paler below with a nearly white belly and a yellowish cast over all; the top of the head and on back to the dorsal fin blackish; greenish bronze reflections over the entire body.

Barbodes binotatus Cuvier and Valenciennes.

Barbodes binotatus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 16 (1842) 168.
Puntius (*Barbodes*) *maculatus* BLEEKER, Atlas Ichth. 3 (1863) 104, pl. 134, fig. 1; pl. 141, fig. 1; and pl. 144, fig. 6.
Barbus maculatus GÜNTHER, Cat. Fishes Brit. Mus. 7 (1868) 123.
Barbus palavanensis BOULENGER, Ann. & Mag. Nat. Hist. VI 15 (1895) 186.
Puntius binotatus WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 3 (1916) 186, fig. 74.

Dorsal IV, 8; anal III, 5; pectoral I, 14–15; ventral I, 8; lateral line, 22–25; transverse line, $\frac{4.5}{2.5}$ or 3; scales from nape to dorsal, 8–9; scales on caudal peduncle, 12; scales between ventral and lateral line 2.5, rarely 3.

Depth from 2.6 to 3 in length, head 3.4 to 3.8; eye 3.5 to 3.9 in head; 1.5 to 1.7 in the broad, gently convex interorbital; snout pointed, with broad, rounded tip, equal to or a seventh longer than eye; mouth terminal, not large, slightly oblique, lower jaw included, maxillary usually extending only to a point beneath nostrils; rostral barbel reaches eye or to middle of pupil; maxillary barbel extends beyond eye or even beyond posterior margin of preopercle; origin of dorsal opposite or behind eighth scale of lateral line, that of ventral behind seventh or eighth scale; fourth dorsal spine slender or of medium stoutness, its upper half noticeably serrate, its height about 1.3 in head, its hard portion about 1.5 times in dorsal height; pectorals 1.3 in head and may reach ventrals or may fall short by the width of a scale; ventrals nearly as long, 1.4 in head, and do not reach anus by the width of one or two scales; their pointed axillary scale as long as or longer than an eye diameter; least height of caudal peduncle 1.1 to 1.3 times in its length, which is 1.5 to 1.8 in head; scales of lateral line usually number twenty-four; other characters as in *B. quinquemaculatus*.

In life the color varies from silvery gray to greenish gray, darker or even blackish green above, paler or nearly white on throat and belly; the following dark or blackish markings are usually present; a large, nearly circular spot on side near base of caudal; a bar just behind operculum on shoulder; two spots between shoulder and caudal, one opposite origin of dorsal, the other opposite origin of anal; occasionally a third spot is added to this row; a large spot or bar at base of anterior dorsal rays; a more or less distinct spot, or traces of one, at anterior part of base of anal. Sometimes there is a dark longitudinal line or even a broad band from shoulder to base of caudal; any or all of the markings may be absent, especially on the larger specimens, except the caudal spot, which seems to be always present.

Color in alcohol similar, but usually considerably darker; often olive brown above and brown or yellowish brown below, with the markings all very distinct.

Here described from many specimens, all from the following localities in Mindanao: At Lake Buluan, Cotabato Province, in October, 1922, I obtained eleven specimens, ranging in length from 38 to 110 millimeters, five of them females with rather well developed eggs. At Ugalingan Piang's landing on the Pulangi, near Fort Reina Regente, I collected thirty specimens in October, 1922; this lot includes one male and one female, each 67 millimeters long, and nearly ready to spawn, and one female, 53 millimeters long, with eggs just beginning to develop; the remainder range in size down to 20 millimeters. Two females, 118 and 97 millimeters, respectively, each with immature eggs, were obtained by me in October, 1922, in a creek at Kidapauan, Cotabato Province; three others collected at the same time were much smaller, the smallest being 21 millimeters in length. Ten specimens, varying in length from 28 to 50 millimeters, were obtained by me in October, 1922, at Kamansa, Davao Province, in a small brook tributary to Saug River.

At the Allen ranch near Cagayan de Misamis, April 20, 1921, I collected twenty specimens from 21 to 50 millimeters in length; in Balongkott Creek, near Linabo, Bukidnon Subprovince, April 23, 1921, twenty-two specimens from 23 to 74 millimeters in length; in Malupali River, at Mailag, Bukidnon Subprovince, April 25, 1921, fifteen specimens, 15 to 67 millimeters in length; in Tagualmay creek on the Fader ranch near Santa Fé, Bukidnon Subprovince, May 2, 1921, seven specimens, from 18 to 63 millimeters in length; from Titunod River near Kolambugan, Lanao Province, forty-five specimens, from 17 to 88 millimeters in length.

Eight specimens, from 30 to 50 millimeters in length, were collected by Alvin Seale in Cagayan River at Cagayan de Misamis in 1908; and one hundred eleven specimens, ranging from 16 to 64 millimeters in length, were collected by Seale and Canonizado at Talacogon, on Agusan River, Agusan Province, in September, 1907.

The specimens from Misamis, Bukidnon, and Lanao differ in color and general form from those collected in other parts of

Mindanao, but it is not likely that they are more than a geographical race.

The dorsal profile is uniformly convex from the tip of the snout to the dorsal; the dorsal spine is not so coarse as shown in Bleeker's figure; the scales on the caudal peduncle seem to be never more nor less than twelve. In young and very small specimens the depth is proportionately less and the head may be equal to the depth, with larger eyes and other juvenile characters.

In the collection of the Bureau of Science are seven specimens, 38 to 78 millimeters in length, collected by Mr. Seale at Puerto Princesa, Palawan, and determined by him as *B. palavanensis* Boulenger. Weber and Beaufort, who have examined the type specimen in the British Museum, consider it a color variety of *B. binotatus.* As these specimens agree in all essentials except the number of pharyngeal teeth, which are 3, 5, 3, 2–2, 3, 5, 3, we may call them *Barbodes binotatus* var. *palavanensis* (Boulenger). A large series of small specimens, many of them spawning, collected at Taytay, Palawan, in May, 1913, also seem to belong to this variety.

I have recently obtained twenty-four specimens, 39 to 96 millimeters long, from Busay River, Basilan, and forty-five specimens, 39 to 107 millimeters long, from Balactasan River, Basilan. With the last mentioned was also collected a very large female in breeding condition, with a length of 167 millimeters, or 213 millimeters over all. The characteristic spots were absent but there can be no doubt that this bulky specimen belongs here. The Basilan specimens were obtained in August, 1923, by G. A. Lopez, fish collector of the Bureau of Science. In Malum River, Tawitawi, Mr. Lopez also caught three specimens, 79, 106, and 162 millimeters in length.

This species seems to be general over the lowlands of Mindanao, and in Basilan, and extends into Palawan. Outside the Philippines it occurs from Sumatra and Singapore to Borneo and Lombok, inclusive.

Barbodes montanoi (Sauvage).

Puntios montanoi SAUVAGE, Bull. Soc. Philomat. 7, 5 (1881) 103.

Dorsal, 11; anal, 7; lateral line, 26; transverse line, $\frac{5}{2.5}$.

Four barbels, the inferior one longer than the superior. Third ray of dorsal bony, smooth, nearly as high as length of head, not including snout. Height of body contained 3.5 times in length of head, 4.5 times in total length; body compressed; profile between dorsal and tip of snout inclined; snout obtuse, without pores, as long as eye, of which the diameter is included, 3.5 times in length of head and 1.5 times in width of interorbital space, lips thick. Two series of scales between lateral line and origin of ventrals. Dorsal inserted an equal distance from end of snout and origin of caudal, which is forked; ventrals a little nearer origin of pectoral than that of anal. Brown on back; four large black spots along lateral line, uniting in an obscure band. Length 90 millimeters.

Simulao River (center of Mindanao), *Montano.*

I have not seen this species, and the above description is translated from Sauvage. Simulao River is a tributary of the Agusan, flowing in from the southeast of Agusan Province, and on which Bunauan is located. Montano, the celebrated French traveler, passed through here in December, 1880.

Barbodes montanoi is evidently very close to *B. binotatus,* but without an examination of the type I do not feel justified in reducing it to the synonymy. If Sauvage is right in saying that the bony dorsal ray is smooth, it is certainly distinct from the other cyprinids known from the lowlands of Mindanao.

Barbodes clemensi sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 15; ventral I, 7; lateral line, 22–24; transverse line, $\frac{5}{2.5}$; 11 scales around the caudal peduncle; scales from nape to dorsal, 8 or 9; pharyngeal teeth, 5, 3, 2–2, 3, 5.

The thick robust body is little compressed, with broad, rounded belly; depth from 3 to 3.3 times in length; head usually a little less than but sometimes equal to depth, and from 3.1 to 3.6 times length; snout short, broad, with a prominent median tubercle, or protuberance, which marks posterior limit of the protractile upper lip, and is contained from 3.16 to 4 times in head; eyes high up, 1.6 to 1.8 times in snout, 1.5 to 2.1 in the broad, gently rounded or nearly flat interorbital space and 6.1 in head; mouth terminal, moderate in size, slightly oblique, 4.2 to 4.66 times in head; the short lower jaw is usually included and is comparatively narrow, its basal width 4.2 to 5 times in head; rostral barbels equal to or slightly longer than diameter of eye; maxillary barbels a little longer than rostral pair; origin of dorsal opposite seventh scale of lateral line; the free margin of fin slightly concave; fourth dorsal spine stout, feebly serrated along upper half of the bony portion which is contained 2.1 to 2.2 times in head; the entire spine from 1.4 to 1.6 times in head: origin of ventrals, which do not reach anus, is opposite eighth scale of lateral line, from which they are separated by one or one and a half rows of scales; pectoral broad, long, 1.3 in head, its tip in the type specimen reaching base of ventral, which is more than 1.8 in head; caudal deeply forked, with pointed lobes, its length 0.8 to 0.88 of head; least height of caudal peduncle from 1.45 to 1.7 in its own length, which is contained 2.2 to 2.7 times in head; lateral line rather faint, descending abruptly from its origin to a point opposite origin of dorsal fin, after which it pursues nearly a straight course along middle of tail; in large specimens the upper profile is a nearly uniform convex curve from tip of snout to origin of dorsal; some smaller specimens have the top of the head flattened, with a marked hump behind nape, behind which profile is gently convex to dorsal; belly profile is a uniform, strongly convex curve from chin to anal fin, the greatest depth being opposite origin of dorsal.

Color in alcohol dusky above, gradually fading on sides to lighter and becoming yellowish or pale flesh color beneath; top of head darkest, or nearly black; fins colorless, concolorous, or dorsal and caudal slightly dusky; specimens in alcohol for sixteen years are nearly uniform brownish with a brassy luster.

Fresh specimens are dark green above, merging into yellow beneath, with golden or brassy luster on sides and belly; fins colorless or reddish.

This fine cyprinid is easily distinguished from the closely related species *Barbodes manalak* by the larger scales and their consequent lesser number, the smaller mouth and lower jaw, and the thick, coarse dorsal spine.

The species is here described from the type specimen, No. 10159, Bureau of Science collection, 188 millimeters long, having a total length of 235 millimeters, obtained by me at Dansalan, Lake Lanao, in May, 1921, and three cotypes, 116 to 137 millimeters long. I have also examined five cotypes, obtained by Joseph Clemens at Lake Lanao in June, 1907, varying in length from 114 to 190 millimeters.

I take pleasure in naming this for my friend Chaplain Joseph Clemens, who with his wife made the first scientific collections around Lake Lanao.

Barbodes amara sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 14; ventral I, 8; lateral line, 22 to 24; transverse line, $\frac{4.5}{2.5}$ or $\frac{4}{2}$; scales from nape to origin of dorsal, 9; scales on caudal peduncle, 11; scales between lateral line and origin of ventral, 2.5 or 2.

The oblong body is rather elevated and much compressed, especially the posterior half, with narrow and little-rounded abdomen; the depth usually equals or may be a trifle more or less than head, 3.12 to 3.6 times in length; eye high up, from 3.14 to 4 times in head and as long or almost as long as the rather pointed snout, the upper surface of which is marked by a median hump and two smaller lateral ones on each side; the flat interorbital space has a low median ridge and is a little wider than the length of snout or eye; mouth terminal, very oblique, posterior margin of maxillary not reaching eye; upper lip thin, very protractile; lower jaw weak, slightly included, even, or somewhat projecting, with a thin lip and a small knob projecting from outer side of symphysis; rostral barbels slender, their length usually much less than, rarely equal to, diameter of eye; maxillary barbels somewhat larger, their length varying from a little less to a little more than diameter of eye; the free or lower edge of the bones of the mandible and the suboperculum curves downward under chin to meet the bones of the other side below eye, leaving only a narrow oval portion free behind chin; upper profile straight from snout to nape, then moderately convex to the region behind dorsal; lower profile uniformly convex from throat to anal; dorsal with a well-developed scaly basal sheath; origin of dorsal nearer tip of snout than base of caudal fin, origin of both dorsal and ventral opposite eighth scale of lateral line; fourth dorsal spine contained from 1.4 to 1.66 times in head, its upper half feebly to moderately toothed, its hard portion 2 to 2.25 times in head; pectorals long, about 1.5 in head, nearly or quite reaching ventrals, which in turn extend to and are 1.7 to 1.8 in head; anal lower than pectoral, its height not much greater than the hard part of dorsal spine; least height of caudal peduncle is 1.35 to 1.5 times in its own length and 2.4 to 2.5 times in head; caudal deeply forked, with pointed lobes, its length 0.8 to 0.9 of head; in one specimen the lateral line has twenty-five tubes on one side, twenty-six on the other; pharyngeal teeth 5, 3, 2–2, 3, 5, their crooked tips hooked; scales with conspicuous longitudinally radiating lines.

Color in alcohol brownish above, merging into yellowish or whitish on sides and belly, with a silvery luster over all; a dark silver band extends from shoulder to middle of caudal; there is a more or less evident blackish band from nape to dorsal fin and top of head is dark also; the fin rays are more or less dusky; lips and tip of snout edged with black; the outlines of each scale above lateral line marked out by a band of very minute black specks.

Here described from the type, No. 9167, and fourteen cotypes in the Bureau of Science collection, all obtained by me at Dansalan, Lake Lanao, Mindanao, September 11, 1922, and varying in length from 66 to 92 millimeters. The largest specimen, which has a length over all of 108 millimeters, is a female filled with immature eggs, as are likewise the smallest specimen and two others of the lot. The only other female had already spawned.

Another lot of fifteen specimens, obtained at the same time and varying in length from 36 to 64 millimeters, contains no sexually mature individuals. Some of this lot have as many as twenty-five or twenty-six scales in the lateral line; those in a transverse series are $\frac{4}{2}$, with two scales between the origin of the ventral and the lateral lines.

I also place here a collection of twenty-five specimens labeled Lake Lanao, July 7, 1910. They are all small, varying from 29 to 80 millimeters in length, most of them being about 40 millimeters long. The largest is a spent female. In this lot the scale count is usually from twenty-four to twenty-six.

The Moro name is *pait*, a word common to many Filipino languages and meaning bitter. The flesh of most of the smaller East Indian Cyprinidæ is bitter, and in Mindanao, outside of Lanao, all cyprinids are known as *pait*.

Barbodes flavifuscus[9] sp. nov.

Dorsal III, 8; anal III, 5; pectoral I, 15; ventral I, 7; transverse line, $\frac{4.5}{3}$; scales on caudal peduncle, 11; scales between nape and dorsal, 9.

Body elongate oblong, dorsal profile low with a decided hump behind nape; depth from 3 to 3.6 times, the long head 2.87 to 3 times in length; posterior margin of eye midway of length of head, or in anterior half; eye from 4.28 to 4.56 times in head and 1.2 to 1.3 in snout; top of head straight or slightly dished, snout elevated, with a central hump and two smaller lateral ones; interorbital space about equals snout, which is 3.3 to 3.4 times in head; mouth large, terminal, little oblique, lips thick, lower jaw included; barbels larger than in *B. katolo,* rostral nearly reaching eye or even extending nearly to pupil; maxillary reaches pupil or may extend beyond posterior margin of eye; third dorsal spine rather stout, feebly dentate, about half as long as head, its hard part 0.8 of its total height; the pectorals are short, 1.7 to 1.8 in head, and do not reach origin of ventrals by the breadth of two scales, while the ventrals are also short, 2 to 2.25 in head, and do not reach vent by two scales; length of caudal peduncle from 2 to 2.1 times in head, and its least depth 0.64 to 0.66, or 1.5 to 1.6 times in its length.

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[9] *Flavus*, yellow; *fuscus*, dusky.

The color of fresh specimens was very dark blackish brown; the color in alcohol is bluish black on snout and top of head and blackish brown dorsally, becoming paler brown on sides and yellowish brown on belly; fins are all dusky.

Here described from a male, the type, 105 millimeters long, No. 9164, Bureau of Science collection, and two cotypes, each 89 millimeters long, obtained by me at Lumbatan, Lake Lanao, in May, 1921; one of the cotypes is a female.

These fish resemble *B. katolo* in appearance and in the characters not otherwise here specified. This species can be distinguished from *B. katolo* by the shorter pectorals and ventrals, the fewer scales between the dorsal and the head, and the coloration. The larger specimen has twenty-four scales in the lateral line on one side, twenty-eight on the other side; the female specimen has twenty-eight on one side, twenty-nine on the other; the other specimen has twenty-four.

It is known as *katapa-tapa* by the Moros at Lumbatan.

Barbodes manguaoensis (A. L. Day).

Barbus manguaoensis DAY, Philip. Journ. Sci. § D **9** (1914) 189, pl. 1, fig. 3.

Dorsal IV, 8; anal III, 8; pectoral I, 15; ventral I, 8; lateral line, 27, rarely 28; transverse line, $\frac{4.5}{3\text{-}3.5}$; scales between lateral line and base of ventrals, 2.5 to 3.5; scales from nape to dorsal, 9; scales on caudal peduncle, 12 to 13; pharyngeal teeth, 3, 5, 3, 2–2, 3, 5, 3.

Body thick, with broad rounded abdomen, elevated, dorsal profile straight from tip of snout to nape, where there is a distinct hump, then strongly convex to dorsal fin; base of dorsal with a high scaly sheath; depth 2.75 to 3.6 in length; head 3.24 to 4; eye 3.5 to 4 1/7 times in head, 1.27 to 1.5 times in the broad snout, and 1.3 to 1.7 in interorbital space, which is 2 to 3.2 in head; mouth very oblique, lower jaw included; rostral barbel equals or slightly exceeds eye, maxillary barbel from 0.1 to 2/7 longer than rostral barbel or eye; origin of dorsal opposite tenth scale of lateral line, fourth spine very broad and strong, moderately serrate, low, but broken so that its height is not accurately determinable; according to Day's figure, about 1.75 in head; pectoral broad, rounded, 1.5 to 1.6 in head, not reaching ventral by the width of two scales; ventral 1.66 to 1.8 in head, not reaching anus by the width of two scales, its origin opposite or behind ninth scale of lateral line; axillary scale 1.3 to 1.4 times diameter of eye, broad, with pointed tip; anal low, 1.75 to 2.18 in head; length of caudal peduncle 1.25 to 1.6 in head, its least depth 1.47 to 1.5 in its length; caudal fin badly damaged.

Color in alcohol faded yellowish brown, darker above; four black spots on side, the largest and most distinct one on lateral line on side of caudal peduncle and before base of caudal fin, the remaining three above lateral line, one above origin of anal, one above origin of ventral, and an elongated area above anterior portion of pectoral, all connected by an indistinct broad black band.

Here described from the type, 94 millimeters long, and a cotype 140 millimeters long, in the possession of Prof. A. L. Day, of the University of the Philippines. Four dorsal spines are plainly evident, not three as given in the original diagnosis.

Thus far this species is known only from Lake Manguao, near Taytay in northern Palawan, where it was collected in 1913 by a joint expedition from the Bureau of Science and the University of the Philippines. It is said to be abundant, biting freely at baited hooks and even nibbling at fingers held in the water. Lake Manguao is a very lonely, seldom-visited sheet of water, briefly described in Professor Day's paper cited above.

Barbodes bantolensis (A. L. Day).

Barbus bantolensis A. L. DAY, Philip. Journ. Sci. § D 9 (1914) 188, pl. 1, figs. 1 and 2.

Dorsal IV, 8; anal III, 5; pectoral I, 14; ventral I, 7; lateral line, 24 to 26; transverse line, $\frac{4.5}{2.5}$; scales between lateral line and origin of ventral, 2.5 or 3; scales on caudal peduncle, 12; pharyngeal teeth, 3, 5, 3, 2–2, 3, 5, 3.

The form of the body varies very markedly even in specimens of the same length, but is more or less oblong elongate, usually elevated dorsally, with a decided hump at the nape, or the upper profile strongly convex; lower profile nearly straight or little arched; body and caudal peduncle thick, only moderately compressed laterally; depth 2.55 to 3.2 in length, head 2.7 to 3.26; eye 4.2 to 5.1 in head, 1.4 to 1.7 in the broad, bluntly rounded snout, and 1.4 to 1.9 in the wide, flat, or nearly flat interorbital space; mouth large, terminal, moderately oblique, upper lip projecting slightly beyond included lower lip; rostral barbel stout, ⅛ longer than eye and reaching its anterior margin; maxillary barbel stronger but not much longer, 1⅜ times eye and extending to middle of eye; origin of dorsal opposite ninth or eighth scale of lateral line, and much nearer caudal than tip of snout; scaly sheath at base of dorsal only moderately developed; fourth spine strong, its height 1.6 to 1.85 in head, the osseous part strongly serrate nearly to its base, its height 1.3 in that of dorsal or 2.3 to 2.7 in head; pectoral rather long, pointed, 1.6 to 1.8 in head, not reaching base of ventral by the width of one or two scales; origin of ventral opposite seventh or eighth scale of lateral line; ventral rather long, its tip not reaching anus by one scale, 1.8 to 1.9 in head, axillary scale ⅑ to ⅐ longer than eye; anal low, 2.3 to 2.7 in head; caudal fin damaged, broadly forked.

Color in alcohol brownish yellow, dusky above, paler below, to very pale yellowish on belly; a dark spot on nape with a more or less evident dark stripe from nape to caudal; an indistinct dark lateral band from shoulder to caudal; a very large dark spot or bar across caudal peduncle near base of caudal fin; a dark elongate blotch behind shoulder; a large dark spot between origin of dorsal and ventral and another circular one between it and caudal spot; fins unmarked; some specimens show dark spot along base of dorsal.

Here described from ten specimens, one of them the type of the species, from 55 to 124 millimeters in length, collected at Lake Manguao, near Taytay, in northern Palawan, as noted under the description of *B. manguaoensis*.

Four dorsal spines are plainly evident, not three as stated in the original description.

Barbodes lanaoensis sp. nov.

Dorsal IV, 8; anal III; pectoral I, 14; ventral I, 8; lateral line, 28; transverse line, $\frac{4.5}{3}$; scales on caudal peduncle, 12; scales between nape and dorsal, 9 or 10.

Body compressed, elevated, dorsal and ventral profiles about equally arched and belly and underside of head broadly rounded; from dorsal to tip of snout may be a straight line, or there may be a slight concavity at nape; depth from 3 to 3.5 times, head from 3.2 to 3.5 times in length; eyes very high, their upper margin flush with profile, and contained 3.5 to 4.3 times in head; posterior margin nearer tip of snout than to posterior edge of operculum; snout rather narrow, blunt, its length equal to an eye diameter or exceeding it by a half; interorbital space equals snout; mouth terminal, oblique, lips of moderate thickness, upper one protractile; barbels much longer than in the related species; rostral barbel longer than eye, extending to pupil or beyond eye; maxillary barbel longer than or twice as long as eye, extending to posterior margin of preopercle or beyond; origin of dorsal nearer tip of snout than root of caudal fin and behind seventh scale of lateral line; outer margin of dorsal concave, fourth dorsal spine from $\frac{2}{3}$ to $5/7$ as long as head, its hard part broad, serrated along its upper half, and $\frac{3}{4}$ as long as dorsal height; pectorals long, 1.35 in head, nearly or quite reaching origin of ventral; origin of ventral behind eighth scale of lateral line, from which it is separated by 2.5 scales; tip of ventrals, which are 1.8 in head, fails to reach anus by the width of a scale or less; anal about half as high as dorsal, its posterior rays reaching hardly half the length of caudal peduncle; length of caudal peduncle contained 1.5 to 1.75 times in head, its least depth 1.4 to 1.6 times in its length; the deeply forked caudal fin a little less than a fourth the length of head and body, its lobes more or less pointed.

The lateral line is curved strongly beneath the dorsal, not reaching a median position until about the fifth scale from the caudal; scales of the lateral line mostly twenty-eight, but twenty-six or twenty-seven in some specimens.

Color in alcohol brownish yellow, upper half darkened, paler below and more or less yellow on belly; anterior dorsal region and top of head dark brown; fins all pale; in some specimens there is a faint dark spot on caudal peduncle, and a faint dark bar on shoulder.

Here described from eight female specimens, varying in length from 78 to 95 millimeters, the largest one 118 millimeters over all. They were all ready to spawn except the smallest one, which had already spawned and had a very few mature eggs left in the ovaries. The specimens were obtained by me at Dansalan, Lake Lanao, May 5, 1921. I also refer here a mature male, collected at the same time and place, and having a length of 94 millimeters; while it does not agree in some particulars, having shorter pectorals and ventrals, it agrees in other essentials. In September, 1922, I obtained two immature males at Dansalan, which were 72 and 75 millimeters, respectively.

The name *kandar* is apparently used by the Moros not only for this species, but also for *B. palata* and other species smaller and less desirable in quality than *B. lindog.*

Barbodes katolo sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 15; ventral I, 8; lateral line, 26; transverse line, $\frac{4.5}{3}$; scales on caudal peduncle, 11; scales between nape and dorsal, 11.

Body elongate oblong, moderately compressed, with dorsal profile rather low and about equal in convexity to ventral profile, or with a pronounced nuchal hump; depth from 3.3 to 3.7 times in length; the thick, clumsy head very long, and contained 2.7 in length; eye very high up, its hind margin halfway between tip of snout and posterior extremity of head; it is contained from 4.5 to 5 times in head and 1.5 times in snout; top of head broad, flat, or slightly dished centrally, interorbital space greater than an eye diameter but not equaling the long, broad, blunt snout, which is 3 times in head; on top of end of snout is a large irregular hump; mouth rather large, terminal, oblique, with included lower jaw; upper lip protractile and moderately thick; lower lip thicker, with lateral flaplike extensions on underside, much as in *Cephalakompsus* and *Ospatulus;* barbels rather weak, short, rostral one equal to half or three-fourths of an eye diameter and not reaching eye; maxillary barbel reaches pupil and is from three-fourths to an eye diameter in length; origin of dorsal nearer caudal than tip of snout and opposite posterior margin of eighth scale of lateral line; outer margin of dorsal straight or slightly concave; fourth spine of medium size, weakly serrate, and half as long as head, its hard part three-fourths of dorsal height; pectorals 1.8 to

1.9 in head, reaching origin of ventrals; origin of latter opposite ninth scale of lateral line, from which it is separated by 2.5 scales; ventrals long, 2.1 to 2.2 in head, their tips reaching within one-half scale of anus; anal moderate, its height about three-fourths of dorsal; length of caudal peduncle contained 2.5 times in head; its depth 0.78 to 0.87 of its length; caudal fin broadly and deeply notched, upper lobe narrower and more pointed, its length a little less than one-fourth that of head and body.

Color in alcohol yellowish brown, dorsal region slightly dusky and top of head brown; fins all pale.

Here described from the type, No. 9161, Bureau of Science collection, 110 millimeters long, and two cotypes, 101 and 95 millimeters long, the smallest one a female. They were obtained by me at Dansalan, Lake Lanao, May 5, 1921; the Moros call them *katolo.*

This fish strongly resembles *Cephalakompsus pachycheilus* but lacks the continuous postlabial groove across the chin; also, the lips are thinner and not rugose, and the barbels are smaller, while the pectorals and ventrals are much longer in proportion.

Barbodes manalak sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 15; ventral I, 7 or 8; lateral line, 24–26; transverse line, $\frac{6}{4}$; scales around the caudal peduncle, 13; scales from nape to dorsal, 11; pharyngeal teeth, 5, 3, 2–2, 3, 5, all more or less hooked at the tip, except that in some specimens the largest teeth may have their tips worn off so that their shape is that of a truncate cylinder.

The deep, robust, oblong body, with very broad and rounded belly, is but little flattened laterally, and the caudal peduncle only moderately so; the depth is equal to the length of the large broad head, and contained from 2.95 to 3.3 times in length of head and body; eyes very high up, prominent, 1.4 to 2 times in snout, 1.8 to 2 times in interorbital space, and 5 to 6 times in head; dorsal profile straight or nearly so from tip of snout to nape where it is more or less strongly elevated; thence it is a low gentle curve to origin of dorsal; interorbital space broad, gently curved from side to side, or flat; in the latter case a median bony ridge is evident; snout wide, short, without prominent protuberances, and contained from 3 to 3.6 times in head; mouth wide, oblique, subterminal, its length 3.4 to 3.7 times in head;

lower jaw strong, broad, rounded, and prominent, more or less projecting, its basal width 3.1 to 3.6 in head; upper lip moderately protractile; rostral and maxillary barbels short, their length varying from the diameter of an eye to half that length; dorsal truncate or nearly so, its origin opposite middle of eighth scale of lateral line, fourth dorsal spine smooth or nearly so and comparatively slender, its length 1.8 to 2 times in head, the length of the stiff portion a little more or less than 3 (2.8 to 3.3) times in head; pectorals 1.45 to 1.55 in head, their tips nearly touching base of ventrals or separated therefrom by half the width of a scale or more; the broad ventrals are 2 to 2.2 in head and do not reach anus by the width of a scale; their origin is behind eighth scale of lateral line and separated therefrom by 2.5 rows of scales; anal truncate, its height equal to or a fourth less than that of dorsal; caudal deeply forked, with pointed lobes, its length from nearly two-thirds to nearly 0.9 the length of head; the least height of caudal peduncle from 2.66 to 2.9 times in its own length, the latter 1.5 to 1.7 times in head; lateral line conspicuous, gently curved toward belly in its forward half.

Color in alcohol dark, nearly black along dorsal surface, becoming paler on sides, and merging into yellowish or golden gray or lighter on belly and throat; interorbital space, snout, muzzle, and opercle blackish; interorbital space, snout, suborbital, and opercle covered with pearly epidermal spots; dorsal fin dusky anteriorly and above and caudal also dusky; the other fins are all pale.

Fresh specimens have the dorsal surface dark green, changing to pale or whitish on sides and overcast with brassy or golden, especially on belly; pectoral and upper angle of dorsal dusky; the rest of the fins pale or with a roseate flush; top of head and snout blackish, with pearly epidermal spots, and also on the suborbital and opercle.

This large and handsome cyprinid is here described from three specimens collected by me in May, 1921, at Dansalan, Lake Lanao, and one specimen collected in June, 1907, by Chaplain Joseph Clemens. The type, No. 9998, has a length of 240 millimeters, or 315 millimeters over all; the cotypes vary in length from 182 to 236 millimeters.

The Moros capture this species in Lake Lanao with gill nets. Though large, this fish is not especially prized for food. The name *manalak* seems to be applied to the two largest species of Cyprinidæ of Lake Lanao.

Barbodes lindog sp. nov.

Dorsal III, 8; anal III, 5; pectoral I, 15; ventral I, 8; lateral line, 28–32; transverse line, $\frac{5.5}{3.5}$; scales on caudal peduncle, 12; scales between nape and dorsal, 11–13.

Body elongate, oblong, thick, not much compressed, dorsal profile evenly convex from snout to caudal peduncle, forming a low flat curve, ventral profile more convex than upper, with full rounded belly, the paired fins short and far apart; depth 3.75 to 4.54 times in length; head equal to depth, or it may be slightly greater, 3.7 to 4.16 in length; eye very high up or it may have the upper margin flush with profile, equal to or slightly greater than the somewhat blunt and round-tipped snout, 3.5 to 4 times in head, with a well-developed gelatinous eyelid, broadest anteriorly; interorbital rather flat, 1.1 to 1.5 more than eye; mouth rather small, terminal, oblique, lower jaw included with upper lip strongly protractile, and thin, continuous lips; rostral barbels very small, their length less than half the diameter of eye; maxillary barbels stouter, equal to or but little greater in length than rostral barbels, never equal to eye; the free margin of dorsal slightly concave, the slender spine smooth or very slightly serrate, its height two-thirds or less the length of head, the stiff portion less than half the length of head; origin of dorsal midway or nearer tip of snout than base of caudal and behind tenth scale of lateral line; ventrals short, 1.8 to 2 in head, reaching halfway to origin of anal, their origin opposite eleventh scale of lateral line, from which they are separated by 3 scales; pectorals short, a little more or less than 1.6 in head; the deeply forked caudal has pointed lobes and is nearly as long as head; lateral line nearly straight; it curves slightly downward to below dorsal, then runs along middle of body to tail; pharyngeal teeth 5, 3, 1, or 4, 3, 1; scales with concentric striæ.

Color in alcohol dusky above, merging into pale or yellowish on sides and belly; a dark stripe along middle of back from nape to caudal fin and a similar band from upper side of operculum to middle of caudal fin; fins all colorless, or with a slight dusky tinge to caudal and dorsal spines.

Here described from sixteen female specimens, ready to spawn or just through spawning, and one ripe male, collected at Dansalan, Lake Lanao, Mindanao. This fish, called *lindog* by the Moros, is caught among the pond weeds of the shallow bays of the lake in enormous quantities. For catching this and other cyprinids the Moros use fine-meshed gill nets. It is the most important fish of Lake Lanao and, next to one called *bau-u-lan,* is their most-prized cyprinid.

My specimens were collected May 4, 1921, and range in length from 100 to 107 millimeters; the longest one is 132 millimeters in length, including the caudal fin.

The ripe females have the body greatly distended both ventrally and (especially) laterally, by the very numerous large eggs.

I have also examined seven females, all ready to spawn, and one ripe male, collected by Chaplain Joseph Clemens at Lake Lanao in June, 1907. In these specimens, which have been in alcohol sixteen years, the stripe has faded and the specimens are dark above, with pale or whitish sides and belly and a brassy luster over all.

Barbodes palata sp. nov.

Dorsal IV, 8; anal III, 5; pectoral I, 14; ventral I, 8; lateral line, 28–32; transverse line, $\frac{5}{3.5}$; scales on caudal peduncle, 12; scales between nape and dorsal, 11–15; pharyngeal teeth, 5, 3, 2–2, 3, 5, all small and crooked.

Body elongated, not much compressed except caudal portion and the narrow, pointed head; ventral profile much more convex than dorsal; depth contained from 3.57 to more than 4 times in length; length of head slightly greater, ranging from $3\frac{1}{3}$ to 3.75 times in length; the large circular eyes very high up, flush or nearly flush with upper profile, and equal to the narrow compressed snout, 3.75 to 4 times in head; interorbital space equal to or may be a very little more or less than eye, and nearly flat; profile from snout to dorsal may form a regular convex curve, or it may be straight to nape, with a more or less pronounced hump behind nape and the remaining dorsal profile nearly flat to caudal; mouth terminal, strongly oblique, with weak jaws, the lower one stronger and projecting, with a knob on the protruding symphysial angle; upper lip thin, lower lip about twice as broad, postlabial groove continuous except at symphysis of lower jaw; ventral part of head noticeably compressed, forming a sharp angle from tip of chin back to breast, but with round belly and caudal peduncle; barbels very short and weak, maxillary ones larger than the rostral, but rarely exceeding half of eye in length; origin of dorsal opposite back part of eighth or ninth or behind ninth scale of lateral line, the rather slender to moderately stout fourth dorsal spine contained 1.5 to 1.7 times in head; its stiff portion serrated along upper half or two-thirds, and contained 1.4 to 1.5 times in height of dorsal; pectorals long, 1.3 to 1.5 in head, tip separated by one scale or less from base of ventral; origin of ventral opposite or a little in advance of dorsal, and separated by 2.5 scales from lateral line; ventral rather short, $1\frac{2}{3}$ to 1.75 in head, not reaching anus by 2.5 scales; anal low, its height less than two-thirds that of dorsal; caudal peduncle rather long, its length 0.64 to 0.72 that of head; its least depth contained 1.66 to 1.9 times in its length and 2.5 to 2.85 times in head; caudal fin deeply forked, with pointed lobes, its length almost or quite equaling depth; lateral line but slightly curved; scales marked by concentric striæ, those on upper half of body also having longitudinal striæ.

Color in alcohol nearly uniform light brownish yellow, becoming more or less shaded with dusky dorsally or on dorsal half; a narrow dusky band from nape to dorsal and back to caudal; a blackish irregular spot often visible on operculum; lips and tip of lower jaw black; fins pale or pectorals, dorsal, and caudal margined with dusky or with dusky rays.

Here described from five females ready to spawn, and five males, varying in length from 97 to 112 millimeters, the longest one 140 millimeters including the caudal fin. They were obtained at Dansalan, Lake Lanao, May 5, 1921.

I have also examined nine nearly ripe females, varying in length from 80 to more than 90 millimeters, one female 96 millimeters long, with the ovaries filled with minute, little-developed eggs, and 7 males from 78 to 94 millimeters long, all collected by me at Dansalan, Lanao, September 18, 1922.

Palata is the Marinao word for narrow, and is applied to this fish by the Moros because of the pinched narrow head, especially along its ventral side.

ILLUSTRATIONS

PLATE 1

Mandibularca resinus sp. nov.

PLATE 2

FIG. 1. *Ospatulus truncatulus* sp. nov.
2. *Cephalakompsus pachycheilus* sp. nov.; × 1.

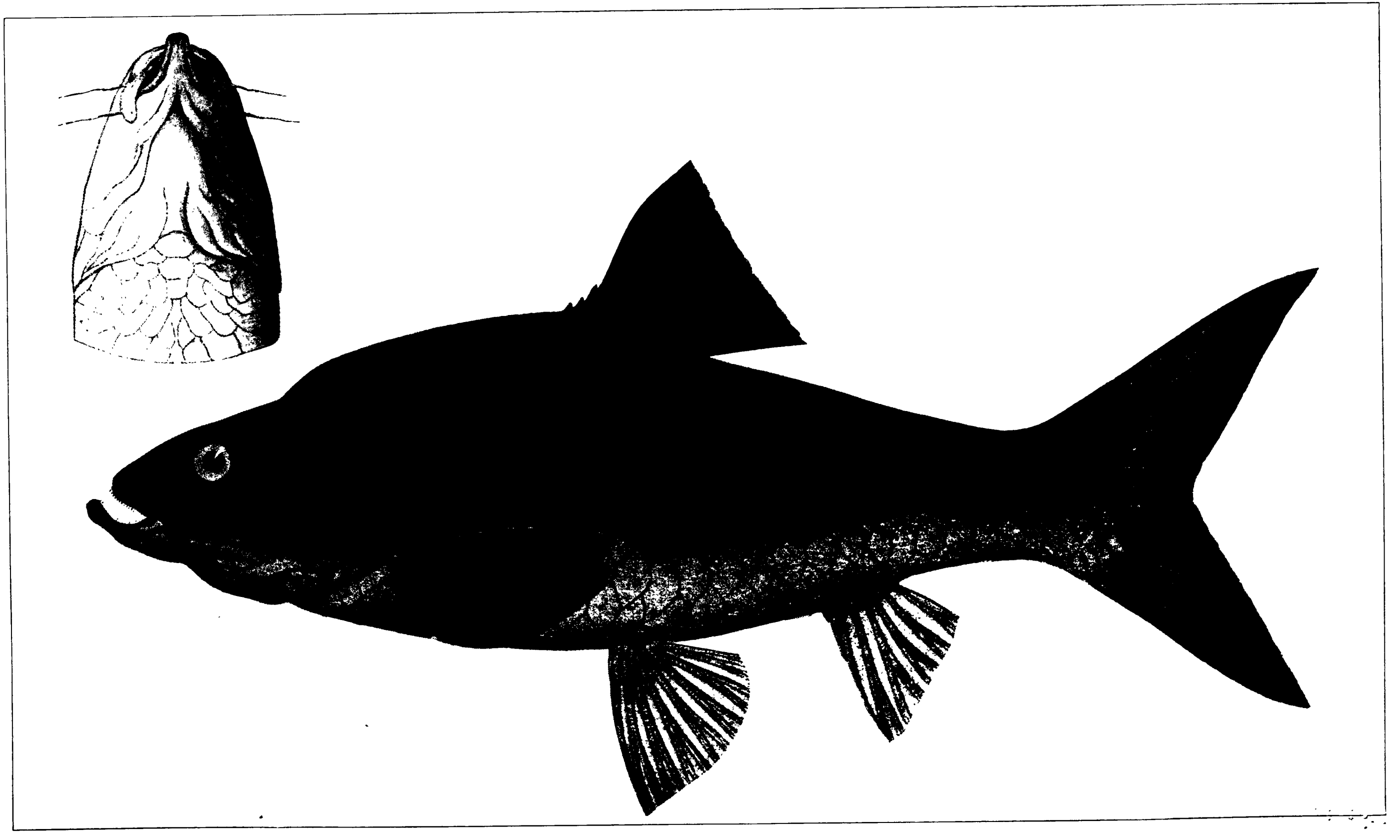
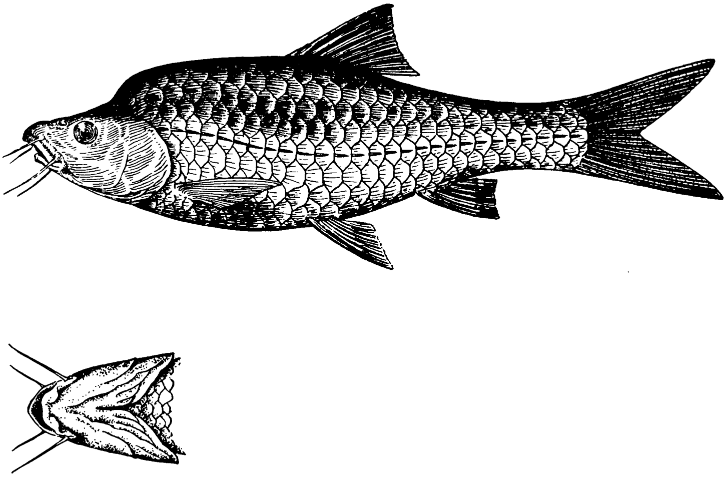


PLATE 1. MANDIBULARCA RESINUS SP. NOV.



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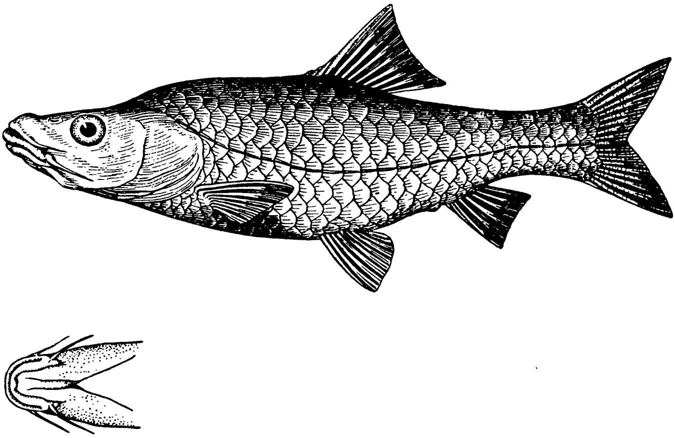

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PLATE 2.

A MONOGRAPH OF THE PACHYRRHYNCHID GROUP OF THE BRACHYDERINÆ, CURCULIONIDÆ: PART I

THE GENUS PACHYRRHYNCHUS GERMAR [1]

By W. SCHULTZE

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(Concluded.)

GROUP V

This group is typified by *Pachyrrhynchus venustus* Waterh. Large species, prothorax in the middle with two dorsolateral spots, no dorsal spot at base, and a large oblong spot at lateral margins. Elytra with roundish, oval, or oblong spots. To the above there is one exception: *P. venustus insulanus* Schultze has no spots at all.

Key to the species of Pachyrrhynchus, Group V.

a^1. Prothorax and elytra with spots.
  b^1. All spots sulphur yellow........................ **P. sulphureomaculatus** Schultze.
  b^2. No yellow spots.
    c^1. Prothorax with the dorsolateral spots small.
      d^1. Prothorax with the dorsolateral spots roundish, reddish, or coppery golden........................ **P. venustus** Waterh.
      d^2. Prothorax with the dorsolateral spots oval, very pale to whitish green .... **P. smaragdinus** Behrens.
    c^2. Prothorax with the dorsolateral spots medium to large.
      e^1. Prothorax with the dorsolateral spots medium oblong-oval, all spots pale lilac or whitish........................ **P. confusus** Schultze.
      e^2. Prothorax with the dorsolateral spots large to very large, not lilac.
        f^1. Prothorax with the dorsolateral spots large, oval, all spots pale reddish........................ **P. rufopunctatus** Waterh.
        f^2. Prothorax with the dorsolateral spots oblong, green.
          g^1. Prothorax with the dorsolateral spots very large, oblong, reaching from posterior almost to anterior margin, all spots pale green; elytra with a violet sheen.
          P. helleri Kuntzen.
          g^2. Prothorax with the dorsolateral spots large, oblong, all spots bright green; no violet sheen on elytra.
          P. apicatus Schultze.
a^2. No spots on prothorax or elytra................ **P. venustus insulanus** Schultze.

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[1] For first half of Part I with Plates 1 to 6 see Philip. Journ. Sci. 23 (1923) 609–673.

Pachyrrhynchus venustus Waterh. Plate 2, fig. 20 (lateral view); Plate 7, fig. 10, ♀.

Pachyrrhynchus venustus Waterh.,[2] Proc. Ent. Soc. London (1841) 18; Trans. Ent. Soc. London I 3 (1841–1843) 310; Ann. & Mag. Nat. Hist. I 8 (1841) 218; Schoenh., Gen. Curc. Suppl. 8 (1845) 381; Schultze, Philip. Journ. Sci. 23 (1923) 80.

Pachyrrhynchus venustus var. β Waterh., Proc. Ent. Soc. London (1841) 18.

Pachyrrhynchus venustus var. γ Waterh., Proc. Ent. Soc. London (1841) 18.

Pachyrrhynchus venustus var. *auromaculatus* Kraatz, Deutsche Ent. Zeitschr. (1888) 27.

Pachyrrhynchus virgatus Schultze, Philip. Journ. Sci. 15 (1919) 549, pl. 1, fig. 1, ♀.

Very glossy black, with reddish or coppery golden scale spots, which are strongly opalescent in fresh specimens. Rostrum in apical half finely and scatteredly punctate, basal half with a shallow depression and a longitudinal medial groove. Front with a roundish scale spot, sides of head below eye with a small squarish spot. Prothorax laterally in the middle between anterior and posterior margins with a roundish scale spot and another, larger, oblong spot at each lateral margin. Elytra impunctate, usually with twenty to twenty-two roundish or short-oval spots. Each elytron with two larger oval spots at base. Three or four spots before the middle form a cross row, the marginal spot of which is elongated and extends backward. At apical third of elytron one or two other roundish spots and another at apical triangle. Also, a bifid sutural spot at the middle and another at apical fourth. Penis structure, Plate 3, fig. 16.

Male, length, 17.5 millimeters (without rostrum); width, 6.5. Female, length, 18 millimeters (without rostrum); width, 7.8.

Mindanao, Surigao Province, Surigao. Dinagat (*Schultze*). Leyte, near Palompon (*V. Elicaño*).

In *Pachyrrhynchus venustus* the number of spots on elytra is variable. Waterhouse founded his var. β on specimens with eighteen spots and var. γ on specimens with sixteen spots. Most commonly this species has twenty-two spots.

[2] Sp. 1. Pachyrrhynchus venustus, W. Niger laevis; capite macula unica interoculos, thorace maculis duabus supra, maculague una ad utrumque marginem, elytris viginti-duabus ovatis ornatis; his a squamis auratis, vel aureo-cupreis, effectis.

Var. β differt elytris maculis octodecim ornatis.

Var. γ differt elytris maculis sexdecim ornatis. Long. corp. lin. 10 ½–7¾.

This species is rather easy to distinguish from related species by the peculiar opalescence of the spots in fresh specimens, and still more so by the very characteristic penis structure.

Pachyrrhynchus venustus subsp. **insulanus** Schultze.

Pachyrrhynchus virgatus subsp. *insulanus* SCHULTZE, Philip. Journ. Sci. 15 (1919) 549.

Uniformly glossy black, without any scale spots or markings. In general form, stouter in build than typical *venustus,* and the elytra appear more inflated and broadly rounded at apex.

SIARGAO and BUCAS GRANDE.

Among the numerous perfect specimens of this unicolorous form from the above localities, none was found which had even traces of spots. In contrast to this fact, among many specimens of *P. venustus* from Surigao, Mindanao, with the usual number of spots, none was found without the spots. A parallel in respect to locality and the same color differences is found in the mimicry form of the above, namely *Metapocyrtus* (*Orthocyrtus*) *schönherri* Waterh. (= *malayanus* Schultze).[3] This species very much resembles *P. venustus* in general appearance and arrangement of spots. A uniformly black local form, *Metapocyrtus schönherri* Waterh. subsp. *atratus* Schultze, is found on Bucas Grande Island and was collected from the same plants as *Pachyrrhynchus venustus insulanus*.[4]

Concerning the species *Pachyrrhynchus venustus* Waterh., I may mention that two other species, *P. rufopunctatus* Waterh. and *P. confusus* Schultze, were wrongly identified and redescribed as the above species by Behrens.[5] Also, Heller's[6] diagnosis is not referable to the above species, but to *P. confusus.* The biological notes[7] on *P. venustus* Waterh. by myself are also based on incorrect determination, the species in question being *P. confusus.*

Pachyrrhynchus confusus Schultze. Plate 2, fig. 18 (lateral view); Plate 7, fig. 5, ♀.

Pachyrrhynchus confusus SCHULTZE, Philip. Journ. Sci. 23 (1923) 81.

Pachyrrhynchus venustus BEHRENS, part., Stett. Ent. Zeitg. 48 (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307;

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[3] Philip. Journ. Sci. 15 (1919) 553.

[4] Philip. Journ. Sci. 23 (1923) 80.

[5] Stett. Ent. Zeitg. 48 (1887) 251–253.

[6] Philip. Journ. Sci. § D 7 (1912) 307.

[7] Philip. Journ. Sci. § D 13 (1918) 276, pl. 1, figs. 10, 11.

SCHULTZE, Philip. Journn. Sci. § D 13 (1918) 276, pl. 1, figs. 10 and 11, 21 (1922) 593, pl. 3, fig. 2.

Black glossy, the elytra very finely rugose, with indistinct interrupted longitudinal rows of punctures. Scale spots very pale lilac, in old specimens sometimes whitish. Rostrum evenly but scatteredly punctate, basal half with an oblong depression and a longitudinal medial groove. Front with a squarish scale spot and another, smaller one below eyes. Prothorax as long as broad, the greatest width at the middle, finely and scatteredly punctate. Laterally, in the middle, between anterior and posterior margins, an oblong-oval spot. At each lateral margin another, larger scale spot. Each elytron with two large oblong-oval basal spots, one discally, the other laterally, sometimes a small roundish spot between the two. Three other spots before the middle, of which the one located at lateral margin is very oblong, reaching backward beyond the middle. On apical third another cross row of two or three spots and a triangular spot at apex. Also, each elytron bears a sutural spot at the middle and another on apical fourth. Apical sutural termination of elytra obtusely pointed in female. Penis structure, Plate 3, fig. 35.

Male, length, 16 millimeters; width, 6.5. Female, length, 17.3 millimeters; width, 7.5.

LUZON, Laguna Province, Los Baños (*Schultze*); in swamp, feeding on the fern *Acrostichum aureum* Linn.

This species was confounded for many years with *P. venustus* Waterh. and *P. rufopunctatus* Waterh.

Pachyrrhynchus rufopunctatus Waterh. Plate 2, fig. 19 (lateral view); Plate 7, fig. 16, ♂.

Pachyrrhynchus rufopunctatus WATERH., Proc. Ent. Soc. London (1842) 45; Trans. Ent. Soc. London I 3 (1843) 311[8]; SCHOENH., Gen. Curc. Suppl. 8 (1845) 382; SCHULTZE, Philip. Journ. Sci. 23 (1923) 80.

Pachyrrhynchus venustus BEHRENS, part., Stett. Ent. Zeitg. 48 (1887) 251; HELLER, Philip. Journ. Sci. § D 7 (1912) 307.

Black, moderately shiny, with pale reddish scale spots. Rostrum sparsely and scatteredly punctate in apical half. Basal half with a shallow depression and a fine medial groove. Front with a large scale spot. Another triangular scale spot below eyes. Prothorax finely and evenly punctate. Laterally with an oblong-oval spot and at each lateral margin a larger scale spot. The position of the spots on elytra is very similar to that in *P. venustus* Waterh.; they are also variable in number, between twenty and twenty-two.

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[8] Pachyrrhynchus rufo-punctatus, Wat. P. niger, brevis, capite maculis tribus, thorace maculis duabus discoidalibus maculaque una ad utrumque marginem; elytris guttis 22 rufo-squamosis ornatis. Long. corp. lin. 8½. Nearly allied to P. venustus.

Male, length, 14.5 millimeters (without rostrum); width, 6.5. Female, length, 17 millimeters (without rostrum); width, 7.

POLILLO (*my collector*).

Specimens of this species I received only from Polillo Island. They agree perfectly with a typical specimen, collected by Cuming, loaned by the British Museum.

This species is slenderer in general form than *P. venustus;* it is most closely related to *P. apicatus* Schultze.

Pachyrrhynchus sulphureomaculatus Schultze. Plate 3, fig. 5 (lateral view); Plate 7, fig. 1, ♀.

Pachyrrhynchus sulphureomaculatus SCHULTZE, Philip. Journ. Sci. 21 (1922) 576, pl. 2 fig. 1, ♀.

Glossy black, with sulphur yellow scale spots. Rostrum in apical half sparsely and scatteredly punctured, basal half with an oblong shallow depression, with a strongly pronounced longitudinal median groove. Front with a round scale spot. Prothorax as long as broad, in the middle toward each side with an oval scale spot and another large oblong spot at each lateral margin. Elytra short-ovate, the surface smooth and impunctate. Each elytron with eleven roundish or oval and two sutural spots, located as follows: Three spots form a cross row at base, three others form another cross row before the middle, of which the one located next to lateral margin is very large and oblong; another very large elongated spot at lateral margin in the middle and four spots in apical third; one small sutural spot is located at the middle, the other at apical fourth. Legs black, femora with an oblong scale spot on underside apically.

Female, length, 15.5 millimeters (without rostrum); width, 7.

MINDANAO, Cotabato Province, Cotabato (*C. M. Weber*).

Pachyrrhynchus smaragdinus Behrens. Plate 9, fig. 6, ♀.

Pachyrrhynchus smaragdinus BEHRENS, Stett. Ent. Zeitg. 48 (1887) 253; KRAATZ, Deutsche Ent. Zeitschr. (1888) 32; HELLER, Philip. Journ. Sci. § D 7 (1912) 307.

Pachyrrhynchus smaragdinus var. *carnosus* KRAATZ, Deutsche Ent. Zeitschr. (1888) 32.

Pachyrrhynchus smaragdinus var. *purpurascens* KRAATZ, Deutsche Ent. Zeitschr. (1888) 32.

Glossy black, prothorax and elytra with pale greenish scale spots. Rostrum dorsally in basal half with a rather shallow depression and an indistinct medial groove; between eyes an indistinct transverse groove. Front with a triangular roundish scale spot, sides of head with another spot below eyes. Prothorax as long as broad, the greatest width in the middle. Dorsally toward each side, in the middle between anterior and posterior margins, a scale spot and another oblong, larger spot at lateral margins. Elytra oblong-ovate, very similar in form to the elytra of *P. confusus* Schultze. Each elytron with eight to ten roundish or short elliptical spots and two sutural spots, one of which is slightly behind the middle, the other at apical fourth. Two large spots at base; three smaller spots form a transverse row before the middle, the dorsolateral one of which is dotlike and very small; one large oblong marginal spot at the middle; three other spots form a cross row behind the middle, the dorsolateral one of which is also very small; and a triangular spot at apex. Mesosternum, metasternum, and first and second abdominal sternites with a spot laterally. Femora with a small spot near apex.

Female, length, 16.5 millimeters (without rostrum); width, 7.5.

Philippines, without exact locality (*Semper*).

The only specimen of this species in my collection, which I obtained in exchange from the Dresden Museum, is labeled "Talaun Insel"? (ex coll. Faust).

The measurements of this species, according to Behrens, are as follows: "Long. 18.5–22 mm. lat. 9.5–10 mm."

This species also seems to be variable with reference to the number of spots on the elytra. The var. *carnosus* and var. *purpurascens* Kraatz seem to refer to color variations of the spots.

Pachyrrhynchus apicatus Schultze. Plate 2, fig. 17 (lateral view); Plate 7, fig. 9, ♀.

Pachyrrhynchus apicatus SCHULTZE, Philip. Journ. Sci. 21 (1922) 575, pl. 3, fig. 1 (penis structure).

Glossy black; head, prothorax, and elytra with large greenish yellow scale spots. Rostrum in apical half fine and scatteredly punctured, basal half with a shallow triangular depression and a medial groove. Front with another very shallow depression beset with a large scale spot. Sides of head with a large scale spot below eye. Prothorax longer than broad, finely regularly scatteredly punctured. A large elongate scale spot in the middle toward each side and another at lateral margin. Elytra oblong-ovate, finely coriaceous, apical termination in female beak-shaped, in male obtusely rounded. Each elytron with ten scale spots; two large oval spots at base, three others forming a cross row before the middle, of which the marginal one is very large and extends posteriorly, two other dorsolateral spots in apical third, and a triangular spot at apex; there are also two sutural spots, one in the middle and the other near apex. Underside of prosternum, mesosternum, and metasternum beset with scales. First and second abdominal sternites with a large spot laterally. Femora with a large scale spot on underside near apex, and an irregular dash of scales above. Penis structure, Plate 3, fig. 34.

Male, length, 17.6 millimeters (without rostrum); width, 7. Female, length, 19 millimeters (without rostrum); width, 8.

POLILLO (*Schultze*).

Pachyrrhynchus helleri Kuntzen. Plate 8, fig. 16, ♀.

Pachyrrhynchus helleri KUNTZEN, Deutsche Ent. Zeitschr. (1914) 452, pl. 13, figs. 1 and 2.

Glossy black, with a well-pronounced violet sheen, prothorax and elytra with pale green scale spots. Form of elytra very similar to that of *Pachyrrhynchus venustus* Waterh. Rostrum in basal half with a prominent depression beset with a scale spot. Another spot at sides of rostrum and head. Prothorax slightly longer than broad, dorsolaterally with a broad stripe reaching from posterior to near anterior margin. Another broad stripe at lateral margins. Elytra uniformly oblong-oval. Each elytron with nine large oval scale spots, two of which are sutural spots, one at about the middle, the other next to apex. Two of the other spots form a cross row at base; three form another cross row in the middle, the latter of which, the marginal spot, is very large and directed backward; and two spots in apical third. Underside; mesosternum, metasternum, and first and second abdominal sternites with a large spot laterally. Femora with a small spot near apex.

Female, length, 16 millimeters (without rostrum); width, 7.3.

LUZON (*Jagor*); exact locality unknown.

This species is very meagerly described by Kuntzen. The only specimen known to me is the type, which I examined in the Zoölogical Museum at Berlin.

GROUP VI

The species of this group are typified by *Pachyrrhynchus multipunctatus* Waterh.; in general form they are similar to the *P. moniliferus* group. Prothorax and elytra with scale spots; prothorax in all species with two discal spots.

Key to the species of Pachyrrhynchus, Group VI.

a^1. General color black.
  b^1. Elytra with a large number of small scale spots. **P. multipunctatus Waterh.**
  $b.^2$ Elytra with large scale spots placed in irregular transverse rows. **P. pseudoproteus Schultze.**
a^2. General color coppery, elytra at base with four large spots and one transverse spot in the middle; total number of spots, twelve. **P. elegans Waterh.**

Pachyrrhynchus multipunctatus Waterh. Plate 1, fig. 29 (lateral view); Plate 5, fig. 9.

Pachyrrhynchus multipunctatus WATERH., Proc. Ent. Soc. London (1841) 20; Ann. & Mag. Nat. Hist. 8 (1841) 219; Trans. Ent. Soc. London I 3 (1843) 322;[9] SCHOENH., Gen. Curc. Suppl. 8 (1845) 385; HELLER, Philip. Journ. Sci. § D 7 (1912) 311.
Pachyrrhynchus auroguttatus CHEVR., Le Naturaliste (1881) 348; HELLER, Philip. Journ. Sci. § D 7 (1912) 303.

Black, moderately glossy, prothorax and elytra with small pale yellowish green scale spots, smaller than eye. Rostrum in apical half coarsely and remotely punctured, in basal half depressed with a shallow roundish impression in the middle, at base near eyes a few wrinkles. Front with a small oblong scale spot. Prothorax as long as broad, with an indistinct anterior submarginal groove, discally with two scale spots and a small spot dorsolaterally at anterior margin. Lateral margins with an irregular stripe. Elytra minutely striate-punctate. Each elytron with three scale spots or dots at base, in the second fourth about eight spots forming an irregular cross row, two small sutural spots in the middle and about twelve small dots scattered in apical third. Mesosternum with a large scale spot, metasternum and first abdominal sternite as well as femora near apex, with a small spot laterally.

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[9] The short Waterhouse description is as follows:

Sp. 18. *Pachyrhynchus multipunctatus*, Waterh.

Ater; capite maculis tribus, earum una interoculari, una utrinque suboculari; thorace nitido, dorso binotato, ad latera lineis duabus; elytris punctis plurimis ornatis; his lineis punctisque viridibus.

This species is equal in size to the *P. moniliferus*, but its form is more elongated. Scarcely a trace of any punctures is observable on the head and thorax. On the elytra are rows of very minute punctures.

Male, length, 11.8 millimeters (without rostrum); width, 5.5.

BOHOL, Sevilla (*Schultze*).

Pachyrrhynchus pseudoproteus Schultze, Plate 2, fig. 8, ♂ (lateral view); Plate 9, fig. 13.

Pachyrrhynchus pseudoproteus SCHULTZE, Philip. Journ. Sci. 21 (1922) 580, pl. 2, fig. 2, ♂.

Black; head, prothorax, and legs glossy, elytra dull, finely coriaceous, with pale green scale spots. Rostrum in apical half scatteredly punctured, basal half with a strongly developed depression, the dorsolateral edges swollen. Front with an oblong-oval scale spot and another on sides of head. Prothorax as long as broad, glossy and impunctate. Discally with two wedge-shaped spots placed transversely close to each other. On the lateral margins two undulated stripes which are confluent at posterior but divergent toward anterior margin. Elytra short-ovate, punctate-striate, the interstices slightly swollen. Each elytron with three spots at base, in the middle two cross rows of about six larger spots, variable in size, between which some smaller dots are located, and an elongated marginal spot. In apical third three more or less laterally confluent spots and a short dorsal longitudinal stripe confluent at apex with an abbreviated marginal stripe. Mesosternum, metasternum, and first abdominal sternite with a spot laterally. Femora with a large spot near apex.

Male, length, 10.8 millimeters (without rostrum); width, 5.

LUZON, Laguna Province (*A. Worm*).

Pachyrrhynchus elegans Waterh.

Pachyrrhynchus elegans WATERH., Proc. Ent. Soc. London (1842) 45; Trans. Ent. Soc. London I 3 (1843) 313; SCHOENH., Gen. Curc. Suppl. 8 (1845) 382; HELLER, Philip. Journ. Sci. § D 7 (1912) 311.

Glossy coppery, prothorax and elytra with pale green scale markings. Prothorax with two oblique discal spots. This species seems to be related to *P. multipunctatus* Waterh. and *P. pseudoproteus* Schultze; since it is known to me only from the literature, I prefer to give the original description of Waterhouse:

> Splendidè cupreus; capite maculis tribus, thorace maculis duabus suprà, maculâque unâ ad utrumque marginem; elytris maculis duodecim ornatis; his maculis magnis et subocellatis, e squamis pallidè viridibus effectis.
>
> Long. corp. 7¼ lin., lat. 3⅜ lin.
>
> This species is considerably larger and more elongated in form than *P. moniliferus*. It is of a brilliant copper colour, and smooth: the forehead and base of the rostrum are concave, and the latter has a deep transverse impression; on the head above is a round spot, and under each eye is an oblong spot. The thorax has two oblique patches above, and a broadish mark on each side. Elytra impunctate, with four largish spots at the base; in the middle of each elytron is a transverse patch, which joins a second longitudinal patch placed on the outer margin; behind the middle are two sutural spots; and on each elytron is a spot very near the apex, and another close above this: all these spots are formed of scales of a very delicate green colour, those on the elytra however have each a scaleless space in the middle. The sides of the meso- and metasternum, and of the two first segments of the abdomen, are adorned with green scales.

Philippines; exact locality unknown.

GROUP VII

This group is typified by *Pachyrrhynchus anellifer* Heller. Small species, elytra very short-ovate, general color black. Eyes rather prominently bulging. Legs relatively long and slender, particularly the tibiæ.

Key to the species of Pachyrrhynchus, Group VII.

a^1. Elytra with well-pronounced longitudinal grooves beset with fine scales, or the grooves circumscribing oblong-oval areas.
  b^1. Elytra with longitudinal grooves .... **P. erosus** Schultze.
  b^2. Elytra with grooves forming oblong-oval scale rings. **P. annulatus** Chevrolat.
a^2. Elytra with slightly impressed, more roundish scale rings, scale dots or regular spots.
  c^1. Prothorax finely coriaceous.
    d^1. Elytra with slightly impressed roundish scale rings. **P. anellifer** Heller.
    d^2. Elytra with small, slightly impressed scale spots or dots forming irregular cross rows .... **P. schuetzei** Schultze.
  c^2. Prothorax smooth, elytra with twenty-eight well-defined scale spots, two of which are bifid sutural spots .... **P. baluganus** sp. nov.

Pachyrrhynchus anellifer Heller. Plate 1, fig. 9, ♀ (lateral view); Plate 6, fig. 17.

Pachyrrhynchus annulatus BEHRENS, Stett. Ent. Zeitg. (1887) 256.
Pachyrrhynchus anellifer HELLER, Philip. Journ. Sci. § D 7 (1912) 324.

Black, glossy, prothorax and elytra with cream or flesh-colored scale ringlets. Rostrum very similar to that of *Pachyrrhynchus annulatus* Chevr. The shallow dorsal depression in basal half with a small bifid scale spot and a well-defined medial groove. Prothorax slightly broader than long, subglobular, remotely punctured, and with a faintly pronounced medial groove. Dorsolaterally in the middle with a more or less distinct ring figure, lateral margins with a scale spot. Elytra short-ovate, faintly and remotely striate-punctate. Each elytron mostly with fourteen roundish scale ringlets, a little larger than eye, two of them at suture near the middle and apex. The other ringlets form three irregular transverse rows; one row at base with four ringlets, the third of which is placed slightly backward; the second row in the middle, also with four ringlets, the marginal one of which is oblong; the third row contains three ringlets; another somewhat triangular ringlet is located near apex.

Mesosternum, metasternum, and first, second, and last abdominal sternites with a scale spot laterally. Femora with a scale spot near apex. Penis structure, Plate 3, fig. 27.

Male, length, 11.5 millimeters (without rostrum); width, 5. Female, length, 12.8 millimeters (without rostrum); width, 6.5.

LUZON, Benguet Subprovince, Irisan River (*McGregor*); Mount Santo Tomas (*Mrs. M. Schultze and W. Schultze*).

Pachyrrhynchus annulatus Chevr. Plate 1, fig. 8, ♀ (lateral view); Plate 6, fig. 19.

Pachyrrhynchus annulatus CHEVR., Le Naturaliste (1881) 348; HELLER, Philip. Journ. Sci. § D 7 (1912) 311; SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 253.

Black, moderately glossy. Elytra with strongly impressed oblong-oval grooves, beset with pale flesh-colored scales. Apical half dorsally strongly swollen, basal half depressed with a shallow impression, beset with a large oblong scale spot, divided by a medial groove reaching to front. Prothorax slightly broader than long, finely and remotely punctured, a well-developed anterior submarginal groove and a narrow scale line along anterior and posterior margins. In the middle an indistinct longitudinal groove. Dorsolaterally a small indistinct irregular ring figure and another ring marking at lateral margins. Elytra short-ovate, finely coriaceous. Each elytron mostly with seventeen oblong-oval ring grooves of which four smaller ones are located subsuturally. The others, which are larger, form three irregular cross rows; a more-triangular ring groove is located near apex. The central part circumscribed by the grooves is distinctly swollen and smooth. Underside, mesosternum, metasternum, and first and second abdominal sternites with a patch of scattered scales laterally. Femora with some scattered scales on underside near apex.

Male, length, 13 millimeters (without rostrum); width, 6. Female, length, 13 millimeters (without rostrum); width, 6.2.

LUZON, Benguet Subprovince, Mount Pulog (*McGregor; F. Relay*).

This species is closely related to *Pachyrrhynchus anellifer* Heller, and in its distribution seems to be restricted to the abovementioned mountain.

Pachyrrhynchus schuetzei Schultze. Plate 1, fig. 10 (lateral view); Plate 6, fig. 18, ♀.

Pachyrrhynchus schuetzei SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 253, pl. 1, fig. 7, ♀.

Black, with a coppery gloss and numerous yellowish white scale ringlets or dots. Rostrum set off transversely in the middle. On basal part a small, double scale spot divided by a longitudinal groove. The latter terminates between eyes and is somewhat shorter, as in *P. anellifer* Heller. Prothorax a little broader than long. Anterior and posterior margins with a fine scale line. A shallow, longitudinal medial groove along which a few scales are located. In the middle, but laterad, a shallow dimple-like depression surrounded by a ring of scales. At lateral margin a group of a few scales. Elytra with irregular rings of scales in transverse rows. The first row parallel to basal margin, each elytron having three large oval rings and four smaller spots. The spaces within the large rings are frequently filled with scales. In the first row the spots are located as follows: A small dotlike spot next to suture, two larger ones in the middle, a few small ones, again one larger, and a small one at lateral margin. The second row runs about parallel to first row, each elytron with four larger and next to lateral margin a few small spots. A third, interrupted row, composed of two rings on each elytron, is located at the beginning of apical third thereof.

Between second and third rows, as well as in apical area of elytron, a subsutural double spot, this being rather long and narrow. In apical triangle a large, irregular, triangular spot. Scattered among the different larger rings of elytra are a number of scaly dots. In the male the elytra are not so glossy as in the female; in the former they have very slight indications of longitudinal furrows, and the spots are more dotlike.

Male, length, 11 millimeters (without rostrum); width, 5. Female, length, 14 millimeters (without rostrum); width, 6.

LUZON, Benguet Subprovince, Pauai (Haight's place) (*O. Schütze; Schultze*).

This species has a superficial resemblance to *P. anellifer* Heller, but I have examined numerous specimens of both species and there are no intermediate forms among them. The differences between the two species seem to be very constant. It appears as if *P. annulatus* Chevr., *P. anellifer* Heller, and *P. schuetzei* are closely related species, which apparently represent transitional stages of their evolution.

Pachyrrhynchus erosus Schultze. Plate 1, fig. 7, ♂ (lateral view); Plate 6, fig. 20, ♀.

Pachyrrhynchus erosus SCHULTZE, Philip. Journ. Sci. **16** (1920) 199.

Black, glossy, elytra with a series of fine shallow longitudinal grooves which form loops beset with creamy white scales. Rostrum in basal half strongly depressed with a bifid scale spot and a sharply defined medial groove extending to front. Prothorax subglobular with a strongly pronounced anterior and posterior submarginal groove. Each elytron with nine or ten longitudinal grooves, respectively, one at suture being common to both elytra, beset with creamy white scales, the grooves forming five loops. The subsutural loop is mostly interrupted, forming several elongate-oval figures; the second, third, and fifth extend from near base to apical fourth. The fourth loop is abbreviated anteriorly. At the apical triangle a triangular loop, which in some specimens is connected with the fifth or marginal loop. Femora with a scale spot apically.

Male, length, 12 millimeters (without rostrum); width, 5. Female, length, 14 millimeters (without rostrum); width, 6.6.

LUZON, Benguet Subprovince, Mountain Trail near Atok (*Schultze*).

Pachyrrhynchus baluganus[10] sp. nov. Plate 2, fig. 2 (lateral view).

Glossy black with brownish sheen. Prothorax and elytra with pale green scale spots. Rostrum dorsally in apical half strongly swollen, basal half flattish depressed with a well-pronounced medial groove and two small scale spots. A small patch of scales on sides of rostrum and a larger spot below eyes. Prothorax broader than long, with an oval scale spot in the middle toward each side. Along anterior margin a fine, more or less interrupted scale line confluent at lateral margins with an oblong scale spot. Another scale line along posterior margin. Elytra short-ovate, with almost obsolete traces of puncture rows. Each elytron with four spots in basal fourth, three spots forming a cross row in the middle, one large marginal spot extending backward from about the middle, three other rather large oval spots forming a cross row in apical third, a small spot and a large triangular spot near apex. Besides those mentioned, two oblong bifid sutural spots behind the middle and at apex. Underside, prosternum, and mesosternum beset with scales; metasternum and first abdominal sternite with a spot laterally. Femora with a scale spot on underside near apex.

Female, length, 13.2 millimeters (without rostrum); width, 6.4.

LUZON, Rizal Province, Mount San Isidro (*Schultze*).

GROUP VIII

This group is typified by *Pachyrrhynchus congestus* Pascoe. Mostly medium-sized to large species. Prothorax dorsally with a more or less triangular rounded spot at base and two dorsolateral spots, one toward each side, before the middle or at anterior margin. Elytra mostly with roundish or oval, well-defined spots; exceptionally the spots longitudinally confluent, forming stripes.

Key to the species of Pachyrrhynchus, Group VIII.

*a*¹. Elytra with oblong spots, longitudinally more or less confluent, forming stripes; prothorax with dorsolateral spots at anterior margin and a triangular spot dorsally at base.
  *b*¹. Spots on elytra elongate, reddish ochraceous, at lateral margins mostly confluent, forming a marginal stripe........ **P. lorquini** Chevr.

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[10] Balugas is a Tagalog name for some denizens of Luzon living in the mountain regions of Rizal Province, who are of mixed Negrito and Tagalog blood.

b^2. Each elytron with four broad longitudinal, brilliant greenish and reddish stripes.. **P. dohrni** Behr.

a^2. Elytra with more or less roundish spots, not confluent longitudinally so as to form stripes.

c^1. Prothorax and elytra apparently uniform black but really with inconspicuous achromatic dull grayish spots; elytra dull black. **P. morio** Heller.

c^2. Prothorax and elytra with conspicuously colored spots.

d^1. General body color black.

e^1. Prothorax with dorsolateral spots at anterior margin.

f^1. Elytra with large more or less contiguous spots.

g^1. Spots dull pale bluish gray with pale reddish margins. **P. congestus** Pascoe.

g^2. Spots dull uniform pale grayish blue. **P. congestus var. immarginatus** Kraatz.

g^3. Spots with brilliant metallic blue center and broad greenish golden margin............................. **P. congestus pavonius** Heller.

f^2. Elytra with spots more or less widely spaced.

h^1. Spots small, uniform light blue. **P. congestus caerulans** Kraatz.

h^2. Spots with conspicuous porcelain white margin, the dark blue center inconspicuous, so that the spots apparently form rings......................... **P. congestus ocellatus** subsp. nov.

h^3. Spots relatively smaller, roundish, uniform pale green. **P. viridans** Heller.

e^2. Prothorax with the dorsolateral spots not reaching anterior margin.

i^1. Spots large and close together; male with sparkling iridescent blue-green spots; female with uniform blue spots not iridescent or sparkling... **P. sanchezi** Heller.

i^2. Spots widely spaced, medium to small.

j^1. Spots dark blue, rather small............ **P. benguetanus** sp. nov.

j^2. Spots pale green, reddish green, or flesh color. **P. sarcitis** Behrens.

d^2. General color not black, but dark purplish.

k^1. Dorsolateral spots at anterior margin. Spots on elytra small, roundish, pale greenish yellow....................... **P. chlorites** Chevr.

k^2. Dorsolateral spots not at anterior margin.

l^1. General color dark reddish purplish wine colored. Size medium.

m^1. Spots on elytra large, rather close together laterally, scales in central part of spots greenish, toward margin reddish. **P. gemmatus** Waterh.

m^2. Spots smaller, more widely spaced. **P. gemmatus purpureus** Kraatz.

l^2. General color blackish purplish with violet sheen. Size large.

n^1. Spots very brilliant, scales in central part blue and green, toward margin reddish golden................ **P. taylori** Schultze.

n^2. Spots very large, touching each other, more uniform brilliant greenish metallic................ **P. taylori metallescens** Schultze.

Pachyrrhynchus congestus Pasc. Plate 1, fig. 20, ♀ (lateral view); Plate 6, fig. 14, ♀.

Pachyrrhynchus congestus PASC., Journ. Linn. Soc. London **11** (1873) 155; BEHR., Stett. Ent. Zeitg. **48** (1887) 249; KRAATZ, Deutsche Ent. Zeitschr. (1888) 28; HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 1; HELLER, Philip. Journ. Sci. § D **7** (1912) 307.

Pachyrrhynchus luteoguttatus CHEVR., Le Naturaliste **3** (1881) 360.

Pachyrrhynchus immarginatus KRAATZ, Deutsche Ent. Zeitschr. (1888) 28.

Glossy black; prothorax and elytra with large eyespots which are slightly impressed. In the central area of these spots the scales are light blue, the marginal rim cream colored, yellowish, or pale reddish. Rostrum in apical half finely punctate, basal half with a deep, roundish depression. Sides of head below eye with a small patch of whitish hairs. Prothorax longer than broad, the greatest width before the middle, very finely and scatteredly punctate. Two scale spots at anterior margin, laterad of the middle; a large scale spot at posterior margin in the middle, and a very large spot at each lateral margin. Elytra elongate-ovate, each elytron with ten or eleven spots and two spots located on suture in apical half. Of the eleven spots two are located at base, four form an irregular cross row before the middle, four are behind the middle, and a more or less triangular spot at apical triangle. Two marginal spots at the middle are sometimes confluent. Fore coxæ also with a scale spot. Mesosternum, metasternum, and first and second abdominal sternites with a spot laterally. Femora with a small spot apically on underside. Penis structure, Plate 3, fig. 18.

Male, length, 11.5 millimeters (without rostrum); width, 4.6 to 6. Female, length, 15 to 17 millimeters (without rostrum); width, 6.3 to 7.3.

LUZON, Benguet Subprovince, Baguio; Mount Mirador; Mount Santo Tomas; Trinidad; Mountain Trail from Baguio to rest house at kilometer 88 (*Schultze*).

This species is also very variable and is found in many local forms, which differ almost solely in regard to the size and the color of the spots on prothorax and elytra. The effect produced by these color and size differences of the spots gives some of the forms the misleading aspect of specific difference. Examination of the penis structure of several of these local forms has revealed no appreciable differences. Concerning these local color variations I wish to take strong exception to the following statement, made by Kraatz,[11] in respect to some of these local forms of *P. congestus* Pasc.:

> Nach der herrschenden Ansicht müssen diese Formen von verschiedenen Fundorten als Arten betrachtet werden; wir sind in diesem Falle im Stande, klar die Verschiedenheit einerseits und die Uebereinstimmungen anderseits auseinander zu setzen und vermögen so zu sagen der Natur in die Geheimnisse ihrer Werkstatt zu folgen.

I consider the specimens from the neighborhood of Baguio to be typical of *P. congestus*. In some specimens the eyespots, due to large size, touch each other only laterally; but in other specimens, particularly from around the regions of Atoc, Benguet, the eyespots are almost all confluent, covering the elytra almost entirely. The component scales of these spots are very small and of a more or less uniform ashy grayish color.

Pachyrrhynchus congestus var. **immarginatus** Kraatz.

Pachyrrhynchus immarginatus KRAATZ, Deutsche Ent. Zeitschr. (1888) 28; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Prothorax and elytra with the spots relatively large, uniformly sky blue or pale grayish blue.

LUZON, Benguet Subprovince, near rest house, kilometer 88, and vicinity of Mount Data (*my collector*).

Other specimens which differ more considerably from the more or less typical forms are the following:

Pachyrrhynchus congestus subsp. **caerulans** Kraatz. Plate 5, fig. 8, ♀.

Pachyrrhynchus coerulans KRAATZ, Deutsche Ent. Zeitschr. (1888) 29; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Glossy black, prothorax and elytra with blue scale spots. Rostrum in form and sculpture very similar to *P. congestus* Pasc. Prothorax longer than broad, the greatest width before the middle, minutely and scatteredly punctate. The spots on prothorax and elytra are usually smaller than in typical *P. congestus*, but their position is exactly the same as in the latter species. The color of the spots is mostly light blue in absolutely fresh specimens; a very narrow marginal ring of each spot is composed of fine bronze green scales.

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[11] Deutsche Ent. Zeitschr. (1888) 29.

Male, length, 13.6 to 15 millimeters (without rostrum); width, 5 to 5.7. Female, length, 14 to 15 millimeters (without rostrum); width, 6 to 6.7.

LUZON, Bontoc and Kalinga Subprovinces, Mount Polis Range (*Taylor; Herre; my collector*).

Some specimens from the vicinity of Lubuagan have the general color dull glossy with a bronze sheen; the color and position of the spots is exactly the same as stated above.

Pachyrrhynchus congestus subsp. **caerulans** var. **robustus** Heller.

Pachyrrhynchus caerulans var. *robustus* HELLER, Deutsche Ent. Zeitschr. (1916) 281.

Very large, prothorax without the dorsal spot in the middle at base, but with a small scale dot dorsolaterally. The spots on elytra as in *caerulans*, only the last two marginal spots confluent.

Length, 19 millimeters; width, 8.

LUZON, Benguet Subprovince, Baguio (*Baker*).

The locality Baguio for this variation seems doubtful to me.

Pachyrrhynchus congestus subsp. **pavonius** Heller. Plate 8, fig. 4, ♀.

Pachyrrhynchus pavonius HELLER, Philip. Journ. Sci. 19 (1921) 543.

Glossy black with purplish or violet sheen. Prothorax and elytra with eyespots located exactly as in the typical form, but somewhat more strongly impressed and well separated. The scales in the central part of the spots brilliant blue, the broad marginal rim metallic golden green.

Male, length, 12 millimeters; width, 4.5. Female, length, 15 millimeters; width, 6.

LUZON, Nueva Vizcaya Province, Imugan (*Baker*).

One specimen, a male, of this beautiful local race of *P. congestus* I received through the kindness of Professor Baker; the type specimen I examined in the Dresden Museum.

Pachyrrhynchus congestus subsp. **ocellatus** subsp. **nov.** Plate 5, fig. 17, ♂.

Glossy black, prothorax and elytra with the eyespots relatively small and more roundish. The central part of the spots dark blue, the narrow marginal rim porcelain white.

Male, length, 15 millimeters; width, 5.8. Female, length, 16 millimeters; width, 7.

LUZON, Benguet Subprovince, settlement Bokod near Mount Pandan (*Schultze*).

Pachyrrhynchus viridans Heller. Plate 7, fig. 6, ♀.

Pachyrrhynchus viridans HELLER, Philip. Journ. Sci. § D 7 (1912) 318.

Black, moderately glossy, prothorax and elytra with pale greenish or bluish green scale spots. Rostrum in basal half with a broad dorsal depression with an indistinct longitudinal groove and a faintly indicated transverse groove at base between eyes. Prothorax as long as broad, greatest width before the middle, rather strongly constricted at base. Toward each side dorsolaterally at anterior margin a squarish spot, dorsally at base a triangular spot, and at lateral margins a large oblong scale spot. Elytra oblong-ovate, very finely coriaceous. Each elytron with eleven or twelve elliptical or roundish scale spots and two sutural spots: Two at base; four forming an irregular transverse row before the middle, of which the second and fourth or marginal spots, are located more posteriorly; another irregular cross row of four spots behind the middle, of which the second and fourth or marginal spots are located slightly forward; and a more or less triangular spot near apex. The two marginal spots are sometimes confluent, forming an elongated spot in the middle. The sutural spots are located, one slightly behind the middle, the other at apical fourth. Underside with the scale markings as in *P. sarcitis* Behr. Femora with a scale spot near apex.

Male, length, 17.5 millimeters (without rostrum); width, 7.
Female, length, 19.5 millimeters (without rostrum); width, 8.2.

CALAYAN, Babuyan group (*McGregor*).

The number of elytral spots in this species seems to be somewhat variable. The general position of the spots is almost identical with that in *P. chlorites* Chevr., but by its size and different shape *P. viridans* can be readily distinguished.

Four specimens before me were collected together with the type (ex coll. Bureau of Science) in December, 1903, by my friend Mr. McGregor, who was involuntarily detained for over six months at the above-named lonesome island.

Pachyrrhynchus chlorites Chevr. Plate 3, fig. 9, ♂ (lateral view); Plate 7, fig. 8, ♀.

Pachyrrhynchus chlorites CHEVR., Le Naturaliste (1881) 360; HELLER, Philip. Journ. Sci. § D 7 (1912) 308, pl. 1, fig. 23.

Pachyrrhynchus rutilans BEHR., Stett. Ent. Zeitg. 48 (1887) 247; KRAATZ, Deutsche Ent. Zeitschr. (1888) 29.

Glossy dark purplish coppery, prothorax and elytra with very pale greenish yellow scale spots. Rostrum dorsally in basal half with a strongly pronounced triangular roundish depression, at base between eyes with a distinct transverse groove. Rostrum and head without any scale spots. Prothorax as long as broad, toward each side, dorsolaterally; at anterior margin with a large transverse spot, dorsally at base with another, more triangular spot, and at lateral margins with a large oblong spot. Elytra oblong-ovate, elytron with eleven roundish scale spots and two spots at suture. The spots, in respect to their relative positions, are located exactly the same as in *P. congestus* subsp. *caerulans* Kraatz, but they are mostly larger in the latter. Mesosternum, metasternum, and first and second abdominal sternites with a large spot laterally. Femora with a dorsally interrupted ring spot near apex.

Male, length, 15 millimeters (without rostrum); width, 6.3. Female, length, 15.3 millimeters (without rostrum); width, 7.

CALAYAN, Babuyan group (*McGregor*).

A large number of specimens, which show very little variation, were collected by Mr. McGregor at the above locality.

Pachyrrhynchus morio Heller. Plate 3, fig. 6 (lateral view); Plate 9, fig. 10, ♂.

Pachyrrhynchus morio HELLER, Philip. Journ. Sci. § D 7 (1912) 318.

Black; head and prothorax glossy, elytra dull, finely coriaceous, with grayish or nearly colorless scale spots, most nearly related to *P. congestus* Pasc. Rostrum dorsally in the middle of apical half depressed, basal half with a deep squarish depression, the dorsolateral edges of rostrum strongly swollen. Prothorax slightly longer than broad, with a scale spot toward each side at anterior margin, another large spot dorsally at base, and an oblong spot at lateral margins. Each elytron with two large roundish spots at base, three spots in apical third, and two bifid sutural spots behind the middle and near apex. Besides these spots, there is sometimes a marginal spot in the middle.

Male, length, 14.5 millimeters (without rostrum); width, 5.5. Female, length, 15.6 millimeters (without rostrum); width, 6.6.

LUZON, Benguet Subprovince, Mount Lusong (*M. Ramos*).

The species seems to be rather variable; the sutural spots are wanting in some specimens.

Pachyrrhynchus gemmatus Waterh. Plate 1, fig. 19, ♀; Plate 6, fig. 13, ♂.

Pachyrrhynchus gemmatus WATERH.,[12] Proc. Ent. Soc. London (1841) 18; Ann. & Mag. Nat. Hist. I 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 311; SCHOENH., Gen. Curc. Suppl. 8 (1845) 382; BEHR., Stett. Ent. Zeitg. (1887) 244; KRAATZ, Deutsche Ent. Zeitschr. (1888) 32; HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 6; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Pachyrrhynchus gemmatus var. β WATERH., Proc. Ent. Soc. London (1841) 18; Trans. Ent. Soc. London I 3 (1843) 311.

Pachyrrhynchus gemmatus var. β BEHR., Stett. Ent. Zeitg. (1887) 244.

Pachyrrhynchus gemmatus var. *atratus* HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

General color glossy dark purplish or coppery to black. Prothorax and elytra with large roundish or oval eyespots, which are beset with very brilliant scales of various hues, those in the central area mostly golden green, and those on the outer portion red or of a metallic coppery hue. Rostrum with a large depression on basal half and a fine longitudinal median groove therein. A bifid scale spot on the depression. Another shallow depression on the front beset with a large roundish spot. Sides of rostrum and head also with a patch of scales. Prothorax as long as broad, the greatest width before the middle, with three large spots dorsally, of which two are located toward the sides dorsolaterally and about midway between fore and hind margins, and one oblong spot in the middle at hind margin. Another very large spot at each lateral margin. Elytra short-ovate, strongly inflated. Each elytron with seven to ten mostly large spots and two sutural spots on apical half. Two spots are located at base, three form a regular cross row before the middle, one oblong spot at margin, three other spots form a triangular figure in apical half, and one somewhat triangular spot is located at apex. Underside of mesosternum and metasternum laterad as well as abdominal sternites, except the last sternite, with patches of brilliant scales. Femora with a subapical scale ring interrupted above.

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[12] Sp. 2. *Pachyrrhynchus gemmatus*, W. Niger vel cupreus, laevis; capite supra maculis duabus, thorace supra tribus, infra duabus, et elytris sexdecim (duabus apud suturam) ornatis; his maculis a congerie squamarum metallice splendentium effectis; squamis centralibus nitidè viridibus, circumgirantibus aureo-rubris, et indè ocellos efficientibus.

Var. β differt elytris maculis viginti-duabus ornatis.

Male, length, 14 millimeters (without rostrum); width, 6.3. Female, length, 15.5 millimeters (without rostrum); width, 7.5.

LUZON, Cagayan Province, Sanchez Mira (*Schultze*), and several specimens from northern Luzon without exact locality.

This species is variable in respect to the number and size of the spots on elytra. Waterhouse describes it as having from sixteen to twenty spots and mentions his var. β with twenty-two spots.

Behrens redescribed this species with twenty-two spots and mentioned a var. β with sixteen spots, contrary to Waterhouse, and Kraatz gives the following constellation formula: "9 (1 scutellari, 2 et 3 disc., 3 lat.), majoribus, ocellatis, sp. major purpurea........................ gemmatus Waterh."

The var. *atratus* Heller is based on a specimen with black as the general color.

Pachyrrhynchus gemmatus subsp. **purpureus** Kraatz. Plate 7, fig. 3, ♀.

Pachyrrhynchus purpureus KRAATZ, Deutsche Ent. Zeitschr. (1888) 31; HELLER, Philip. Journ. Sci. § D 7 (1912) 308.

Glossy, very dark purplish red, prothorax and elytra with brilliant light green scale spots, mostly much smaller than in typical *P. gemmatus*. Prothorax with the dorsolateral spots located nearer the middle. Each elytron with seven or eight oval or roundish spots and two bifid spots at suture. Two oval spots at base, two or three roundish spots forming a cross row before the middle, two others at apical third, the marginal one of which is oblong, and one other spot at apex. The first sutural spot in the middle is usually large and oblong, the second sutural spot at apical fourth is usually small.

Male, length, 13.5 millimeters (without rostrum); width, 5.6. Female, length, 14 millimeters (without rostrum); width, 6.3.

LUZON, Cagayan Province, Sanchez Mira (*my collector*).

By the general form and different aspects this subspecies may be readily distinguished from typical *P. gemmatus* Waterh.

Pachyrrhynchus taylori Schultze. Plate 2, fig. 15, ♀ (lateral view); Plate 7, fig. 11, ♀.

Pachyrrhynchus taylori SCHULTZE, Deutsche Ent. Zeitschr. (1922) 37, pl. 1, fig. 1, ♀.

Related to *P. gemmatus* Waterh. but larger and relatively slenderer in build. Very glossy dark purplish with a violet sheen and large, very brilliant eyespots on prothorax and elytra. Rostrum toward apex distinctly divergent, broader than at base. Basal half with a broad dorsal impression beset with a large golden, usually bifid (by a fine and indistinct groove), somewhat triangular scale spot. Front with a shallow depression bearing a more roundish spot, still another spot at sides of rostrum and head. Prothorax a little longer than broad, the greatest width before the middle. Dorsally at hind margin a subtriangular scale spot, toward each side near anterior margin an elliptical or roundish spot, and on the lateral margins a still larger oblong scale spot. Elytra in the female rather broad and short-ovate, in the male slenderer, with sixteen more or less roundish eyespots, seven of which are located on each elytron, and two at suture are common to both elytra. Two spots at base, two at the middle, one oblong spot at outer margin extending backward beyond the middle, two at apical third, and two spots in apical half at suture. Scales in the outer marginal region of the spots reddish golden, the central part lighter and darker blue and green, glistening brilliantly like precious stones. In the male the spots are usually smaller than in the female; some male specimens have, besides the above-mentioned spots, a small roundish spot dorsolaterally in the middle and another toward each side between the sutural spots. Underside of mesothorax, metathorax, and first abdominal sternite laterad with a scale spot. Femora with scale spot apically below.

Male, length, 15.8 millimeters (without rostrum); width, 6.8. Female, length, 17 millimeters (without rostrum); width, 8.

LUZON, Kalinga Subprovince, Balbalan (*Taylor; Herre*). Because of its striking coloration, *Pachyrrhynchus taylori* is the most conspicuous species of the genus known to me. Mr. Taylor informs me that among the Kalingas this species is well known as *kokóng*.

Recently I received through Doctor Herre several more specimens of this species; among them were two males in which the color of the spots is exactly the same as in the females. In my original description I considered as the male of *P. taylori* a specimen which has the spots very large and of a more uniform color. Upon careful examination I now find that this specimen is not the male of typical *taylori*, but represents a well-differentiated subspecies of that species. This particular specimen was, as Mr. Taylor informs me now, probably collected not at Balbalan but on Mount Polis. Lately I received through Doctor Herre, also from Mount Polis, a female which agrees perfectly with the above-mentioned male.

Pachyrrhynchus taylori subsp. metallescens subsp. nov. Plate 2, fig. 14, ♂ (lateral view); Plate 7, fig. 12, ♂.

Pachyrrhynchus taylori SCHULTZE, Deutsche. Ent. Zeitschr. (1922) 37, part., pl. 1, fig. 2, ♂.

Spots on head, prothorax, and elytra much larger than in typical *Pachyrrhynchus taylori*. Spots more uniform metallic reddish golden in the male, and in the female greenish golden. Spots in the male are so large that they touch each other; in the female they approach each other closely. Form of elytra in both sexes rather regular oblong-ovate, but slenderer in the male. Penis structure similar in general shape, but slightly broader than in typical *P. taylori*.

Male, length, 17.5 millimeters (without rostrum); width, 6.5. Female, length, 17.5 millimeters (without rostrum); width, 8.3.

LUZON, Ifugao Subprovince, Polis Pass (*Taylor; Herre*).

Pachyrrhynchus sanchezi Heller. Plate 2, fig. 16, ♀ (lateral view); Plate 6, fig. 15, ♀; fig. 16, ♂.

Pachyrrhynchus sanchezi HELLER, Philip. Journ. Sci. § D 7 (1912) 319, pl. 2, fig. 10, ♂.

Glossy black with large scale spots which are brilliant green or blue, glimmering like precious stones in the male; in the female the spots are uniform blue. Rostrum in apical half very finely and scatteredly punctured, basal half with a large and oblong depression reaching to front. A bifid triangular scale spot in the depression, divided by a fine median line. Front with a roundish spot, sides of rostrum and head also with a patch of scales. Prothorax longer than broad, the greatest width before the middle. Dorsally at posterior margin a large subtriangular scale spot, before the middle toward each side a large roundish spot, and at each lateral margin a very large oblong scale patch. Elytra in the male oblong-elliptical, in the female short-ovate. Each elytron with seven large scale spots and two sutural spots in apical half located as follows: Two spots at base; three form a cross row at middle, of which the marginal one is very large and directed backward; two in apical third: and two at suture. Underside of mesothorax, metathorax, and first abdominal sternite laterally with a large scale patch. Femora with a scale spot on underside near apex. Penis structure, Plate 3, fig. 20.

Male, length, 11 to 12.5 millimeters (without rostrum); width, 5 to 6.2. Female, length, 15 to 16 millimeters (without rostrum); width, 7 to 7.5.

LUZON, Benguet Subprovince, Baguio; Mount Mirador; Mount Santo Tomas; Mountain Trail from Baguio to near kilometer 30.

From the above localities I obtained a number of specimens, some of them in copula; but this species seems to be rather rare. In my experience in collecting this species I found that perfect specimens with reference to the scale coloration are rare and it appears that the scales wear off very easily. In *P. sanchezi* Heller it is noteworthy that the scale coloration of the markings in the male, being brilliant and glimmering green, differs from that of the female, which is uniform blue. In the Deutsche Entomologische Museum at Berlin I located a female specimen labeled *P. immarginatus* Kraatz, which was very old and in a worn state, that belongs to this species.

Pachyrrhynchus benguetanus sp. nov. Plate 3, fig. 10 (lateral view); Plate 7, fig. 2, ♂.

Glossy black, prothorax and elytra with roundish uniform dark blue spots. Rostrum dorsally in basal half with a broad depression and an indistinct medial groove, the depression confluent with another, shallower and more roundish depression on front, both depressions bearing a large scale spot. Sides of rostrum and head also with a large blue scale spot. Prothorax longer than broad, toward each side dorsolaterally a small roundish scale spot and dorsally at base another oblong spot, these spots sometimes entirely absent or only indicated by traces. Sides with a large oblong spot. Elytra with indistinct traces of puncture rows; position of spots similar to that in *P. sanchezi* Heller but spots very much smaller. Each elytron with eight spots and one small sutural spot in the middle. Two spots at base, three forming a cross row before the middle, of which the first dorsolateral spot is usually very small, sometimes entirely absent; a large marginal spot slightly behind the middle, a roundish spot at apical third, and another spot near apex. Underside marked very similarly to that of *P. sanchezi.* Femora with an indistinct spot near apex.

Male, length, 13.6 millimeters (without rostrum); width, 6.5. Female, length, 13.2 millimeters (without rostrum); width, 7.

LUZON, Benguet Subprovince (*Baker*).

The elytra of this species are relatively shorter than in *P. congestus* Pasc. The number of spots in *P. benguetanus* seems to be rather variable, since in one specimen no sutural spot is present; in another specimen on each elytron the two spots nearest to apex are also missing.

Pachyrrhynchus sarcitis Behr. Plate 3, fig. 2, ♀ (lateral view); Plate 7, fig. 4, ♀.

Pachyrrhynchus sarcitis BEHR., Stett. Ent. Zeitg. 48 (1887) 246; KRAATZ, Deutsche Ent. Zeitschr. (1888) 32; HELLER, Philip. Journ. Sci. § D 7 (1912) 308, pl. 1, fig. 22.

Glossy black, prothorax and elytra with pale green or pale flesh-colored scale spots. Rostrum dorsally in basal half with an oblong depression which is confluent with another depression on front. Both depressions with a larger and a smaller spot, bifid by an indistinct medial carina. Another scale spot at sides of rostrum and head. Prothorax as long as broad, the greatest width slightly before the middle, very minutely punctate. Toward each side dorsolaterally, but before the middle, a rather squarish spot, and dorsally at base a large subtriangular spot. Lateral margins with a scale stripe reaching from anterior to posterior margin. Elytra ovate; each elytron with eight roundish or oval spots and two bifid spots at suture. Two oval spots at base, three roundish spots form a transverse row before the middle, a large oblong marginal spot in the middle, another large roundish spot dorsolaterally in apical third, and a large apical spot. The bifid sutural spots are located, one behind the middle, the other at apical fourth. Mesosternum, metasternum, and first and second abdominal sternites with a large spot laterally. Femora with a spot near apex.

Male, length, 15 millimeters (without rostrum); width, 6.6. Female, length, 17.3 millimeters (without rostrum); width, 7.5.

CALAYAN, Babuyan group (*McGregor*).

Professor Kraatz placed this species in his group 5 as not having a dorsal spot at the base of the prothorax, which is in disagreement with Behrens's original description.

Pachyrrhynchus lorquini Chevr. Plate 3, fig. 8 (lateral view); Plate 8, fig. 2.

Pachyrrhynchus lorquini CHEVR., Le Naturaliste (1881) 360; HELLER, Philip. Journ. Sci. § D 7 (1912) 308, pl. 1, fig. 24.

Pachyrrhynchus flavopunctatus KRAATZ, Deutsche Ent. Zeitschr. (1888) 30.

Pachyrrhynchus flavomaculatus KRAATZ, Deutsche Ent. Zeitschr. (1888) 32.

Glossy black with a violet sheen, prothorax and elytra with pale reddish or ochraceous scale spots. Body form very similar to that of *P. congestus* Pasc. Rostrum in basal half with a short shallow triangular depression. Prothorax longer than broad, greatest width before the middle. At anterior margin toward each side dorsolaterally a roundish scale spot and a large spot dorsally at base. A broad stripe at lateral margins. Elytra with two oblong sutural spots, one at the middle, the other at apical fourth. Each elytron furthermore with seven oblong-oval spots; one at the base, three forming an irregular cross row before the middle, three others behind the middle; and a broad marginal stripe reaching from base to apex. The marginal stripe is sometimes interrupted, forming three or four oblong spots. Anterior coxæ with a scale spot. Mesosternum, metasternum, and first and second abdominal sternites with a scale spot laterally. Legs glossy bluish black with a scale spot near apex.

Male, length, 13 millimeters (without rostrum); width, 5.2. Female, length, 16 millimeters (without rostrum); width, 6.

LUZON, Laguna Province, Mount Maquiling (*Baker*).

This species is described from a specimen collected by Lorquin at Maldonado (?) which locality is unknown to me in the Philippines. The species is easily recognized by the peculiar coloration of the scale markings.

Pachyrrhynchus dohrni Behrens. Plate 8, fig. 15.

Pachyrrhynchus dohrni BEHRENS, Stett. Ent. Zeitg. 48 (1887) 236; HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 8; HELLER, Philip. Journ. Sci. § D 7 (1912) 306.

Glossy dark purplish coppery, prothorax with brilliant greenish or reddish golden scale markings. Rostrum in basal half with a shallow triangular depression. Prothorax slightly broader than long, subspherical, more constricted near base. Dorsally with a triangular spot at base, at anterior margin toward each side dorsolaterally a roundish spot, and at lateral margins an oblong longitudinal spot. Elytra ovate, near the lateral margins and apex indistinctly striate-punctate. Each elytron with four broad longitudinal scale stripes, an apical spot and two small oblong sutural spots behind the middle and near apex. The first or dorsal and the fourth or marginal stripes longest, reaching from base to near apex. The second stripe dorsolaterally, the shortest, is much abbreviated and only about half as long as the first. The third stripe is slightly shorter than the fourth. The scale coloration of the stripes is very brilliant, glistening with greenish or reddish coppery reflections. Mesosternum, metasternum, and first and second abdominal sternites with scale patches laterally. Femora with a small scale spot on underside near apex.

Pachyrrhynchus dohrni var. β Behrens.

Pachyrrhynchus dohrni var. β BEHRENS, Stett. Ent. Zeitg. 48 (1887) 236.

Elytra without the posterior sutural spot.

Length, 15 to 19 millimeters; width, 5.5 to 8.

Philippines (*Semper*); exact locality unknown.

GROUP IX

This group contains at present only two species and is typified by *Pachyrrhynchus eques* Heller. Both species are characterized by the peculiar general coloration of the elytra, which is dull or glossy burnished, reddish or greenish bronze.

Key to the species of Pachyrrhynchus, Group IX.

a^1. Without any scale markings.................................... **P. sumptuosus** Schultze.
a^2. Prothorax and elytra with light blue scale spots............ **P. eques** Heller.

Pachyrrhynchus eques Heller. Plate 8, fig. 3.

Pachyrrhynchus eques HELLER, Philip. Journ. Sci. § D 7 (1912) 312, pl. 1, fig. 21.

Dull reddish or greenish bronze, legs coppery, elytra with light blue scale spots. Rostrum with the dorsal depression rather shallow. Prothorax as long as broad, smooth and glossy, with a small scale spot at lateral margins. Elytra ovate and impunctate. Each elytron with two roundish basal spots and five smaller spots in apical third, of which four form an irregular transverse row, the other being located near apex. Another small bifid sutural spot slightly behind the middle. Mesosternum, metasternum, and first and second abdominal sternites with scale patches laterally. Femora with a spot on underside near apex.

Female, length, 19 millimeters; width, 7.8.

LUZON, Cagayan Province, Abulog River (*McGregor*).

This species is known to me only from the type specimen (ex coll. Bureau of Science) in the Zoölogical Museum of Dresden.

Pachyrrhynchus sumptuosus Schultze. Plate 3, fig. 4, ♀ (lateral view); Plate 5, fig. 5.

Pachyrrhynchus sumptuosus SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 250.

Head, prothorax, legs, and underside glossy black, with a coppery luster. Elytra dull glossy, iridescent purplish brown or green. Rostrum finely and sparsely punctured, a prominent pitlike depression in basal half. In the depression a rather indistinct longitudinal groove. Prothorax with an indistinct groove near fore margin, laterally only. Hind margin raised. Female with a group of very minute bronze green scales at lateral margin. Each elytron with a row of punctiform impressions near outer margin, extending from middle to apex. In apical part these depressions run together, forming a groove. Femora with a strongly excavated depression below, apically. At the depression minutely fine scales and hair. Tibia below very minutely denticulate and beset with fine hair. Penis structure, Plate 3, fig. 21.

Male, length, 12.5 millimeters (without rostrum); width, 5. Female, length, 16 millimeters (without rostrum); width, 7.

LUZON, Kalinga Subprovince, Lubuagan and Balbalan (*Taylor*).

This species is easily recognized by the very peculiar general coloration of the elytra, which indicates its relation to *P. eques* Heller.

GROUP X

This group is typified by *Pachyrrhynchus inclytus* Pascoe. Large species, general color dark green, dark glowing red, or black. Prothorax and elytra mostly with prominent longitudinal, exceptionally with transverse, scale stripes. This group corresponds mainly, with some exceptions and additions, to Heller's second group.

Key to the species of Pachyrrhynchus, Group X.

a[1]. Elytra black with a transverse band in the middle.
  b[1]. Elytra with the narrow dorsal longitudinal stripes not interrupted, entire .... **P. möllendorffi** Heller.
  b[2]. Elytra with the dorsal longitudinal stripes interrupted before and behind the transverse band in the middle........ **P. semperi** Heller.
a[2]. Black, dark green, or glowing red, without an entire transverse band in the middle, but mostly with longitudinal stripes.
  c[1]. Dark glowing red, each elytron with four moderately broad longitudinal stripes, traces of a more or less interrupted sutural scale line, and narrow interrupted secondary stripes. **P. pulchellus** Behrens.
  c[2]. Elytra with a transverse row of spots in the middle. **P. pulchellus var. bakeri** Heller.
  c[3]. Elytra with three rather broad longitudinal stripes. **P. pulchellus var. modestioroides** Schultze.
   d[1]. Dark green or black, each elytron with three longitudinal stripes.
    e[1]. Dark green, prothorax with a dorsobasal triangular spot and toward each side a short longitudinal stripe extending from

base forward to beyond the middle, where it is usually expanded spotlike. Each elytron with three rather broad longitudinal stripes. In the middle between the stripes two or three spots indicating a rudimentary transverse band. **P. inclytus** Pascoe.

e^2. Each elytron with three broad stripes but without any spots in the middle.......................... **P. inclytus** var. **modestior** Behrens.

f^1. Prothorax with the dorsolateral abbreviated stripes connected by a short transverse stripe. Elytra with a more or less interrupted crossband at the middle. **P. inclytus** var. **transversatus** Heller.

f^2. Black; prothorax dorsolaterally in the middle with or without an indistinct small roundish spot. Each elytron with three narrow stripes.. **P. igorota** Schultze.

d^2. Black; each elytron with more than three longitudinal stripes, the latter more or less interrupted.

g^1. Prothorax with a band along anterior margin and dorsally at hind margin another bandlike marking composed of two transverse spots, dorsolaterally near the middle with two small round spots. Each elytron with five broad stripes, the sutural one abbreviated at base.................................... **P. loheri** Schultze.

g^2. Prothorax with two large dorsolateral spots at anterior margin, two small dots at the middle, and two others at base. Each elytron with two sutural spots at the middle and near apex, and four stripes, the first and second mostly interrupted, abbreviated near base.................................. **P. psittaculus** Heller.

h^1. Elytra without distinct stripes.

h^2. Elytra with a sutural spot at the middle and near apex. A large irregular scaled area at basal third extending laterally to, and expanding again at, apical third. **P. psittacinus** Heller.

Pachyrrhynchus pulchellus Behr. Plate 1, fig. 13, ♀ (lateral view); Plate 4, fig. 14, ♀.

Pachyrrhynchus pulchellus BEHR., Stett. Ent. Zeitg. 48 (1887) 238; KRAATZ, Deutsche Ent. Zeitschr. (1888) 32; HELLER, Philip. Journ. Sci. § D 7 (1912) 306.

Pachyrrhynchus bakeri HELLER, Philip. Journ. Sci. 19 (1921) 542.

Pachyrrhynchus bakeri var. *modestioroides* SCHULTZE, Philip. Journ. Sci. 21 (1922) 576.

Dark glowing red, glossy, with pale bluish green longitudinal stripes. Nearly related to *P. inclytus* Pasc. Rostrum with a strongly pronounced, somewhat triangular depression in basal half which is confluent with a shallow depression on front. The latter with a small round scale spot. Sides of rostrum and head with an oblong patch of scales. Prothorax broader than long, the greatest width before the middle. At anterior margin toward each side a wedge-shaped spot and two other elongate spots at hind margin, the former and latter sometimes confluent. Sides with a longitudinal stripe. Elytra oblong-oval, glowing or coppery red. Each elytron with four longitudinal stripes, and with a more or less fragmentary scale line along suture in apical half. The first dorsal stripe and the fourth or marginal stripe reach from base to apex, at which place they are confluent. The second and third stripes reach from base to apical fourth and there join each other. Underside of prothorax, mesothorax, and metathorax with scale patches, the first three abdominal sternites with spots laterally. Femora with a scale spot on underside near apex. Penis structure, Plate 3, fig. 38.

Male, length, 12.8 to 14.5 millimeters (without rostrum); width, 5 to 5.8. Female, length, 14 to 16 millimeters (without rostrum); width, 5.8 to 7.

LUZON, Benguet Subprovince, Baguio; Mount Mirador; Mount Santo Tomas; Trinidad; Mountain Trail from Baguio to kilometer 88; Mount Polis (*Schultze*).

This species is also quite variable, especially in the width of the stripes. The latter are in some specimens very narrow, like lines (from Pauai, Benguet, at Haight's place, 2,400 meters) and only in rare instances the stripes attain the same width as in *P. inclytus*. In some specimens of *P. pulchellus* small elongate spots are present between the stripes in apical half of elytra; in some cases such spots are located only in the middle, forming a cross row. The latter form I consider to be var. *bakeri* Heller, Plate 8, fig. 5. It resembles somewhat *P. gloriosus* Faust. From Mount Polis I received specimens which I described as *P. pulchellus* var. *modestioroides* Schultze; this variation has on each elytron only three relatively broad stripes and on that account resembles *P. inclytus* Pasc., but may be distinguished readily from the latter by the smaller size, other ground color, and the different markings on the prothorax.

Pachyrrhynchus inclytus Pasc. Plate 1, fig. 12, ♀ (lateral view); Plate 4, fig. 13, ♀ (var. *modestior* Behr.).

Pachyrrhynchus inclytus PASC., Journ. Linn. Soc. London **11** (1873) 155; BEHR., Stett. Ent. Zeitg. **48** (1887) 242; HELLER, Philip. Journ. Sci. § D **7** (1912) 306; SCHULTZE, Philip. Journ. Sci. **21** (1922) 577; **23** (1923) 78.

Pachyrrhynchus modestior BEHR., Stett. Ent. Zeitg. **48** (1887) 240, var. *β*, op. cit. 241, var. *γ*, l. c., var. *δ*, l. c.; KRAATZ, Deutsche Ent. Zeitschr. (1888) 26; HEYDEN, 42. Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 5; HELLER, Philip. Journ. Sci. § D **7** (1912) 306.

Pachyrrhynchus modestior var. *apicalis* KRAATZ, Deutsche Ent. Zeitschr. (1888) 26.

Pachyrrhynchus modestior var. *transversatus* HELLER, Philip. Journ. Sci. **19** (1921) 544.

Glossy dark green, elytra with pale green longitudinal scale stripes. Nearly related to *P. pulchellus* Behr. Rostrum in apical half scatteredly punctate and with a shallow depression, basal half with a strongly pronounced depression. Front with a large oblong-triangular scale spot. Sides of rostrum and head also with an oblong spot. Prothorax as long as broad, the greatest width at the middle. A wedge-shaped spot in the middle at hind margin and laterad of it a short, slightly curved longitudinal stripe reaching forward to beyond the middle where it is expanded spotlike. Another broad stripe at lateral margins. Elytra oblong-ovate, very finely coriaceous, each elytron with three longitudinal stripes. A subsutural and a marginal stripe reaching from base to apex, confluent at the latter place. Another stripe intermediate between the two, not reaching apex. In the middle, near suture and between the first and second stripes, some spots that form a rudimentary crossband. Sometimes a small spot between first and second stripes in apical fourth (var. δ Behr. and var. *apicalis* Kraatz). Femora with large scale spots near apex. Penis structure, Plate 3, fig. 37.

Male, length, 13.5 to 17 millimeters (without rostrum); width, 5.5 to 7.5. Female, length, 16 to 19 millimeters (without rostrum); width, 7 to 8.5.

LUZON, Benguet Subprovince, Baguio; Mount Mirador; Mount Santo Tomas; Trinidad; Mountain Trail from Baguio to rest house, kilometer 58: Nueva Vizcaya Province, Imugan (*Schultze*).

I consider specimens in which the spots in the middle of elytra are wanting to be var. *modestior* Behr. The typical form of *P. inclytus* Pasc. is identical with *P. modestior* var. γ Behrens. Still another form is var. β Behr. (thorace antice plaga connectiva inter vittas laterales), being similar to *P. modestior* var. *transversatus* Heller; finally, var. δ Behr. and var. *apicalis* Kraatz are identical.

Pachyrrhynchus inclytus is found mostly in the same localities as *P. pulchellus* Behr., but seems to be rarer. It is readily distinguishable from the latter by the abbreviated stripes on the prothorax as well as by the triangular spot in the middle at base. In systematic relation *P. inclytus* stands between *P. pulchellus* Behr. and *P. igorota* Schultze.

Pachyrrhynchus igorota Schultze. Plate 1, fig. 11, ♂ (lateral view); Plate 4, fig. 16, ♀.

Pachyrrhynchus igorota SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 251, pl. 1, fig. 2, ♀; 21 (1922) 593, pl. 4, fig. 1.

Dull glossy, black. Rostrum apically broader than at base. Apical area densely punctured. Rostrum transversely set off at the middle, posterior of which is a deep depression, the lateral edges of which are strongly produced. A creamy white scale spot posterior of antennal groove. Prothorax as long as broad. Laterad of the middle an irregular spot composed of a few scales and posteriorly of the latter at hind margin a wedge-shaped spot. A longitudinal lateral fascia from fore to hind margin. Each elytron with three longitudinal narrow creamy white stripes: One from base straight across disk to apex; another laterad, beginning a short distance from base and terminating a short distance before apex; and another broad outer marginal stripe also arising some distance from base and terminating before apex. Prosternum and mesosternum with a triangular spot between coxæ, the latter also with a spot laterad. Metasternum and first abdominal segment with a lateral spot only. Femora with a spot on underside near apex. Penis structure, Plate 3, fig. 22.

Male, length, 18 millimeters (without rostrum); width, 7.
Female, length, 20 millimeters (without rostrum); width, 8.5.

LUZON, Benguet Subprovince, Pauai (Haight's place), 2,400 meters; Mount Pulog (*Schultze*).

The males of this species have the spots on prothorax mostly very much reduced or entirely absent. Also the stripes on elytra, with the exception of the one at lateral margin, are sometimes interrupted in the middle. In one specimen the second stripe is reduced to one-fourth the normal length basally. This species is mostly covered with a sticky substance, so that it is very difficult to obtain perfectly clean specimens. Whether this is due to a kind of natural perspiration or to certain peculiarities of the food plant with which the insect comes in contact, I am unable to say at present.

The range of this species seems very limited. It is closely related to *P. inclytus* Waterh., but is easily distinguished from the latter by the usually larger size, the narrower stripes on the elytra, and the absence of a spot between the eyes. The color of *P. inclytus* is mostly dark glossy green, but in all the specimens of *P. igorota* that were examined the color is dull glossy black.

Pachyrrhynchus loheri Schultze. Plate 1, fig. 14 (lateral view); Plate 4, fig. 15, ♀.

Pachyrrhynchus loheri SCHULTZE, Philip. Journ. Sci. § D 12 (1917) 252, pl. 1, fig. 3, ♀.

Glossy black, elytra with very broad, light green, longitudinal scale stripes. Rostrum comparatively short, transversely set off and emarginate in the middle. Apical part densely punctured, in basal part a deep depression with a scale spot, the lateral edges prominently produced. Front with a punctiform impression. Prothorax longer than broad. A broad band at anterior margin, which narrows toward sides, but continues to hind margin where it terminates laterad in a shallow depression. Hind margin dorsad with a broad band composed of two elongated, closely approximated spots. Somewhat behind the middle, laterad, a shallow depression with a nearly round scale spot. From the latter to posterior margin a slightly raised keel. Elytra cordiform, broadest before the middle. Each elytron with five longitudinal stripes, which are broader than the interspaces, except the sutural stripes. The latter begin before the middle, becoming somewhat narrower and again broader toward apex. The second stripe unites with the marginal near apex. The interspaces are somewhat elevated. Abdominal sternites finely wrinkled like leather and with a few scattered scales. Femora with a spot near apex, entad.

Female, length, 18 millimeters (without rostrum); width, 8.

LUZON, Bulacan Province, Mount Guinuisan (*A. Loher*).

From other related species *P. loheri* is easily distinguished by the cordate elytra.

Pachyrrhynchus psittaculus Heller. Plate 1, fig. 15 (lateral view); Plate 8, fig. 7, ♀.

Pachyrrhynchus psittaculus HELLER, Philip. Journ. Sci. 19 (1921) 543, pl. 2, fig. 6.

Glossy black, scale markings pale green, closely related to *P. loheri* Schultze. Rostrum with the dorsal depression well defined, transverse oval. Head and prothorax almost imperceptibly remotely punctate. Prothorax with an irregular more or less interrupted scale band at anterior margin, which is mostly expanded spotlike dorsolaterally. A spot dorsolaterally in the middle and two small spots dorsally at base. Lateral margins with a larger or smaller scale band. Each elytron with four longitudinal stripes and two sutural spots near the middle and apex. The dorsal stripe is more or less interrupted, forming oblong spots, but in the type specimen it is confluent at apex with the marginal stripe. The second and third stripes are abbreviated basally and apically; furthermore, in the type specimen the second stripe is also interrupted in the middle. Underside, mesosternum, metasternum, and first and second abdominal sternites with a scale spot laterally. Femora with a spot near apex.

Female, length, 14 millimeters (without rostrum); width, 6.5.

LUZON, Laguna Province, Mount Banahao (*A. Duyag*).

Through my collector I received a single specimen (see Plate 1, fig. 15) of this species from the above-mentioned type locality, which varies somewhat from the type specimen, Plate 8, fig. 7.

Pachyrrhynchus psittacinus Heller. Plate 8, fig. 1.

Pachyrrhynchus psittacinus HELLER, Philip. Journ. Sci. § D 7 (1912) 317, pl. 1, fig. 16, ♂.

Glossy black, elytra with very large pale bluish green scale markings. Rostrum with a scale spot in the dorsal triangular depression, some scattered scales on side, another spot below eye. Prothorax longer than broad, greatest width before the middle, dorsally finely and scatteredly punctured. At anterior margin toward each side a lateral scale spot and a small spot dorsolaterally in posterior half. Surface of elytra beset with pale green scales, with the exception of the following bare markings: A sutural stripe, confluent with a broad irregular bare area in the middle, continued along suture to apex and as a stripe along outer margin; a small subsutural scale spot behind the middle and near apex; the scatteredly scaled area shows traces of narrow bare stripes, which seems to indicate that the large scaled configuration is the result of confluence of oblong spots or stripes. Femora with a scale spot apically.

Male, length, 15.2 millimeters; width, 6.

LUZON, Bataan Province, Lamao (*H. M. Cuzner*).

On account of its peculiar markings, this species is easily recognizable. The only specimen known so far (ex coll. Bureau of Science) seems to be the type, now in the Dresden Museum.

Pachyrrhynchus möllendorffi Heller. Plate 8, fig. 10.

Pachyrrhynchus möllendorffi HELLER, Abh. u. Ber. Königl. Zool. Anthr.-Ethnogr. Mus. Dresden 7 (1898–99) 5; Philip. Journ. Sci. § D 7 (1912) 305, pl. 1, fig. 18.

Black, glossy, head and legs coppery with a purplish sheen. Prothorax and elytra with pale green scale-stripe markings, very similar to *P. chevrolati* Eydoux and Souleyet. Rostrum dorsally in basal half with an almost squarish depression, which is more or less confluent with a shallow depression on front, the latter beset with a small scale spot. Apical part of rostrum also slightly depressed in the middle, so that the dorsolateral edges appear swollen. Sides of head with a small scale spot below eye. Prothorax broader than long, the greatest width before the middle, glossy, finely and scatteredly punctured. Toward each side dorsolaterally a longitudinal stripe reaching from base to anterior margin and continued anterolaterally, then again confluent with a longitudinal stripe at lateral margin, the latter reaching posterior margin. Elytra more oblong than in *P. chevrolati,* very finely striate-punctate. Each elytron with three longitudinal stripes, one dorsolaterally in the second interstice, another in the sixth interstice reaching only to the middle, and a marginal stripe which is confluent near apex with the dorsal stripe. At base a transverse stripe and in the middle another transverse stripe, more or less interrupted by the puncture rows, laterally confluent with the second longitudinal stripe. In apical fourth the first or dorsal stripe with a short, forward-curved branch reaching to seventh puncture row. Underside with scale markings as in *P. chevrolati.* Femora with a small scale spot on underside near apex.

Length, 15 millimeters; width, 6.5.

Philippines; exact locality unknown.

This species I know only from the type specimen in the Zoölogical Museum, Dresden.

Pachyrrhynchus semperi Heller. Plate 8, fig. 14.

Pachyrrhynchus semperi HELLER, Philip. Journ. Sci. § D 7 (1912) 314.

Glossy, black, prothorax and elytra with narrow pale reddish golden scale stripes. Rostrum in basal half dorsally with a well-pronounced triangular depression, bearing a transverse scale spot; laterally before eye with an elongate depression, so that the dorsolateral edges are distinctly swollen. Prothorax slightly longer than broad, at base more constricted than near apex, very minutely and scatteredly punctate, with a narrow scale line at anterior and posterior margins, lateral margins with a longitudinal stripe confluent with the latter. Dorsolaterally a short fragmentary longitudinal stripe near posterior margin, not quite reaching latter. Elytra elongate-cordiform, toward apex indistinctly striate-punctate, the first row near apex depressed, apical part of first interstice swollen and rugulose. Basal half in third and seventh interstice with a longitudinal stripe, both stripes mostly connected at base but not reaching posteriorly up to a tranverse stripe located slightly behind the middle. The transverse stripe is continued as a marginal stripe in apical half to near apex, where it recurves again and forms an abbreviated longitudinal stripe in the third interstice, not reaching the transverse stripe. Another apically abbreviated longitudinal stripe at apical half in the seventh interstice, confluent with the transverse stripe, and an elongate subsutural spot near apex. Mesosternum, metasternum, and first and second abdominal sternites with a scale patch laterally. Femora with a circular scale band near apex.

Female, length, 16.8 millimeters (without rostrum); width, 7.

Philippines (*Semper*); exact locality unknown.

GROUP XI

The typical species for this small group is *Pachyrrhynchus gloriosus* Faust. Medium-sized species, general color dark glowing red or dark purplish coppery. Prothorax and elytra with scale stripes and more or less interrupted transverse bands.

Key to the species of Pachyrrhynchus, Group XI.

*a*¹. Elytra with the dorsal longitudinal stripe continuous to near apex, crossed in the middle by a transverse band........ **P. gloriosus** Faust.

*a*². Elytra with the dorsal longitudinal stripe interrupted, before and behind the transverse band.

- *b*¹. Prothorax with two dorsolateral longitudinal stripes.
  - *c*¹. Elytra, dorsal stripe interrupted a short distance before and behind the transverse band. The latter interrupted only at suture. **P. nobilis** Heller.
  - *c*². Elytra, dorsal stripe reduced to a spot at base and a short branch at apical third. Transverse band interrupted at suture and dorsolaterally forming a transverse spot. **P. gloriosus abbreviatus** Schultze.
- *b*². Prothorax with a medial and two dorsolateral longitudinal stripes; each elytron at base, besides the dorsal, with two abbreviated stripes, at apical triangle with one or two oval spots.... **P. cumingi** Waterh.

Pachyrrhynchus gloriosus Faust. Plate 1, fig. 26 (lateral view); Plate 4, fig. 7, ♀.

Pachyrrhynchus gloriosus FAUST, Stett. Ent. Zeitg. (1895) 7; HELLER, Philip. Journn. Sci. § D 7 (1912) 305, pl. 1, fig. 15.

Glossy dark coppery red, prothorax and elytra with pale green scale stripes. Rostrum in apical half finely and remotely punctate, basal half with a strongly pronounced triangular depression. Front mostly with a small scale spot, another spot at sides of rostrum and head. Prothorax slightly broader than long. Toward each side dorsolaterally a longitudinal stripe extending from base to and confluent with an anterior marginal stripe. The latter continued laterally and confluent with a lateral marginal stripe, which again is confluent with a short stripe laterally at posterior margin. Elytra stout-ovate, finely punctate-striate. Each elytron with three longitudinal stripes, the first dorsolaterally between the second and third puncture rows sometimes interrupted in the middle, reaching from base to apex; the second, laterally between the sixth and seventh puncture rows, is curved in apical fourth and becomes confluent with the first stripe; the third or lateral marginal stripe extends from base to apex where it is confluent with the first stripe. Furthermore, the elytra with a stripe at base and a transverse stripe at the middle. Apical fourth mostly with a small sutural spot. Prosternum and mesosternum beset with scales, metasternum and first abdominal sternite with a spot laterally. Femora with an oblong spot in the middle and another small spot on underside near apex. Penis structure, Plate 3, fig. 36.

Male, length, 13 millimeters (without rostrum); width, 5.8. Female, length, 13 millimeters (without rostrum); width, 6.3.

LUZON, Laguna Province, Mount Banahao (*Schultze*).

Pachyrrhynchus gloriosus subsp. **abbreviatus** Schultze. Plate 4, fig. 8, ♂.

Pachyrrhynchus gloriosus var. *abbreviatus* SCHULTZE, Philip. Journ. Sci. 21 (1922) 576.

Dark glowing red, the scale markings in the general design as in the typical form, but broader and abbreviated so as to form oblong spots. Prothorax dorsolaterally at base with a large oblong spot, sometimes another small spot dorsolaterally at anterior margin. Lateral margins with a large elongate scale patch. Each elytron with two oblong spots at base, and a transverse spot in the middle dorsolaterally, the latter being a fragmentary part of the transverse stripe. Lateral marginal stripe reduced at base, reaching from basal fourth to apex where it is confluent with a short and abbreviated part of the first stripe. Laterally at the middle a short branch of the transverse stripe confluent with the marginal stripe.

LUZON, Bontoc Subprovince (*my collector*): Kalinga Subprovince, Lubuagan (*Herre*).

Based on one specimen, I considered this subspecies at first to be only a variation of *P. gloriosus* Faust. Recently, I received several more specimens which show rather strong and constant differential characters, distinguishing it from typical *P. gloriosus.* The prothorax is more subspherical, and the elytra are more oblong-oval in subsp. *abbreviatus.* Furthermore, the pale green scale markings are very brilliant.

Pachyrrhynchus nobilis Heller. Plate 8, fig. 12.

Pachyrrhynchus nobilis HELLER, Philip. Journ. Sci. § D 7 (1912) 313, pl. 2, fig. 9.

Purplish or violet coppery with sulphur or pale ocherous yellow stripes. Rostrum in the dorsal depression with a scale spot, the latter bifid by a medial groove. Sides of rostrum and head with an oblong spot. Prothorax subspherical, slightly broader than long, impunctate, with a scale line along anterior and posterior margins, and a longitudinal line at each lateral margin confluent with the latter. Toward each side dorsolaterally a short longitudinal line reaching from posterior margin forward to the middle. Elytra finely striate-punctate. At basal third an abbreviated longitudinal line at second and eighth interstices, which are confluent with a curved line at base, a transverse line at about the middle reaching laterally to the eighth puncture row, then bending backward to near apex where it is confluent with a short longitudinal line, in the second interstice, reaching forward to near the transverse line. In apical third, in the fourth and sixth interstices, a short abbreviated line and two small subsutural spots. Mesosternum and metasternum with a small scale spot laterally. Femora with a small spot on underside near apex.

Length, 11 to 14 millimeters; width, 5 to 6.8.

Philippines (*Semper*); exact locality unknown.

Pachyrrhynchus cumingi Waterh.

Pachyrrhynchus cumingi WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 312; SCHOENH., Gen. Curc. Suppl. 8 (1845) 382; HELLER, Philip. Journ. Sci. § D 7 (1912) 309.

Glossy reddish coppery or dark greenish bronze, prothorax and elytra with pale green stripe markings.

I prefer to give here the original description of Waterhouse,[13] since two specimens before me which I believe to be this species and which agree in practically all characters with *P. cumingi* seem to represent a variety on account of some minor differences in the markings.

Splendidè cupreus; elytris leviter punctato-striatis; rostro notâ transversâ basali, capite maculis oblongis tribus, harum una inter-oculari, una utrinque suboculari; thorace lineis marginalibus, et suprà lineis tribus, et unâ transversâ interruptâ, notato; elytris lineâ marginali, lineisque duabus longitudinalibus dorsalibus, nec non lineâ transversâ per medium excurrente, atque lineis duabus abbreviatis et ad angulos basales, et ad subapicales; his lineis maculisque pallide cyaneo-viridibus.

Long. corp. 6¾ lin., lat. 3 lin.

This beautiful species is rather larger than *P. moniliferus;* the rostrum is proportionately broader and rather shorter, the thorax is also broader and rather less constricted before and behind, and the elytra are proportionately narrower and more elongated: it is of a rich copper-red colour, but presents a slight æneous tint in parts and in certain lights. The rostrum is very delicately punctured and has a shallowish transverse impression in a line with the base of the antennæ, there is also a broad and very shallow oblong depression on the head—both these depressions are filled with pale blue-green scales, and there is a patch of similar scales on each side beneath the eye and another on the side of the rostrum. The thorax is smooth, has a transverse blue-green line in front and another behind, and these lines are joined by a broader mark on the sides, which passes close to the femora; on the upper surface are three longitudinal marks, and one central transverse mark; this latter is slightly interrupted, otherwise the disc of the thorax would be divided into four areas. The elytra are faintly punctured, and the punctures form striæ; on the apical portion of the elytra the punctures are more distinct: a line of scales borders the outer margin of each elytron, extending from the base almost to the apex: at the base it is recurved and runs up towards the suture, but stopping at a short distance from the suture it sends off a longitudinal line which extends very nearly to the apex of the elytra and there joins the marginal line; this longitudinal line is slightly interrupted in the middle of the elytra, where there is a transverse band. Besides these lines, all of which are formed of pale blue-green scales, there are two abbreviated longitudinal marks running from the base of the elytra on each side, and two small spots situated on the apical half of each elytron.

Pachyrrhynchus cumingi var. boholensis var. nov. Plate 9, fig. 19, ♀.

Prothorax with the medial stripe slightly interrupted in the middle, at base triangularly expanded. The dorsolateral longitudinal stripes before the middle expanded spotlike, but no transverse line indicated. Markings of elytra exactly as in the original description, except one rather large spot situated on apical half of each elytron.

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[13] Trans. Ent. Soc. London I 3 (1843) 312.

Male, length, 13 millimeters (without rostrum); width, 5.5. Female, length, 14 millimeters (without rostrum); width, 6.2.

BOHOL, Bilar (*M. Ramos*).

This species in its general aspect has a slight resemblance to *P. gloriosus* Faust, but the elytra of *P. cumingi* are more elongate.

GROUP XII

This group is typified by *Pachyrrhynchus ardentius* Schultze and contains only one other species, *P. corpulentus* Schultze. In general body form the species resemble some of the species of the *congestus* group.

Key to the species of Pachyrrhynchus, Group XII.

a^1. Prothorax with an irregular longitudinal stripe toward each side dorsolaterally. Elytra with stripes and a transverse band, forming a somewhat triangular figure in basal half.... P. corpulentus Schultze.

a^2. Prothorax with an irregular spot toward each side dorsolaterally. Elytra with the markings more interrupted than in the former species. P. ardentius Schultze.

Pachyrrhynchus ardentius Schultze. Plate 3, fig. 11, ♀ (lateral view); Plate 4, fig. 1.

Pachyrrhynchus ardentius SCHULTZE, Philip. Journ. Sci. 15 (1919) 550, pl. 1, fig. 7, ♀.

Glossy glowing purplish red with pale green markings and spots. Rostrum as broad as long, a strongly pronounced cross groove at middle from which there extends to the front a shallow depression, the lateral edges of which are strongly raised. Front densely and finely punctured. Sides of head with a scale spot. Prothorax slightly broader than long, with a posterior submarginal groove. A small triangular scale spot at the middle laterad and a large oblong patch at each lateral margin. Elytra with very faint traces of rows of punctures. Each elytron with the following markings: Three spots at base, one of which, near the lateral margin, is large and oblong; at the middle a small spot discally and a band extending laterally; along margin a large oblong spot, almost confluent with a small triangular spot at apex; beyond the middle at suture a small spot; another sutural spot near apex. Between the last-mentioned spots, somewhat laterad, a long dash, and laterad of the latter two other spots. Femora with a scale spot apically below.

Length, 16.5 millimeters; width, 7.8.

SIARGAO (*Schultze*).

The spots on the elytra in this species seem to vary, since in the above-described type, the only perfect specimen I received, the second basal spot on the left elytron is absent.

Pachyrrhynchus corpulentus Schultze. Plate 2, fig. 5, ♀ (lateral view); Plate 4, fig. 2, ♀.

Pachyrrhynchus ardentius subsp. *corpulentus* SCHULTZE, Deutsche Ent. Zeitschr. (1922) 41, pl. 1, fig. 14, ♀.

Glossy glowing red, the scale markings pale yellowish green. Related to *P. ardentius* Schultze, but the elytra more short-ovate and more strongly inflated. Rostrum in basal half with a shallow depression and an oblong groovelike dentation. Front with an approximately triangular scale spot, another spot at sides of rostrum and head. Prothorax longer than broad, impunctate, with an anteriorly and posteriorly abbreviated longitudinal stripe located laterad of the middle, another broader stripe at each lateral margin. Elytra impunctate, each elytron with a dorsal scale stripe reaching from base to apex but interrupted at the middle, confluent at apex with a marginal stripe. At about the middle an abreviated crossband which is confluent with the dorsal stripe, thus forming a triangle in basal half. Inside the latter an oblong longitudinal and another oblique spot. In apical half a short longitudinal stripe parallel to the marginal stripe and in the dorsolateral area an oblong oblique spot. Aside from the above markings a small subsutural spot behind the middle and another near apex. In the male the indicated markings are more disconnected or interrupted than in the female. Femora with a small patch of scattered scales apically below.

Male, length, 13 millimeters (without rostrum); width, 5.6. Female, length, 14.5 millimeters (without rostrum); width, 7.

MINDANAO, Bukidnon Province, Lindabon (*Schultze*).

This species I described originally as a subspecies of *P. ardentius* and it is undoubtedly related to the latter, but it is sufficiently distinct to merit specific rank.

GROUP XIII

This group is typified by *Pachyrrhynchus pinorum* Pasc. The species pertaining to this group differ strikingly in general appearance from the other species of the genus. Large and slenderly built species, general color black. Prothorax always longer than broad. Elytra very oblong-ovate. Scales very minute and rudimentary, mostly grayish.

Key to the species of Pachyrrhynchus, Group XIII.

*a*¹. Elytra with well-pronounced longitudinal grooves and ridges.
  *b*¹. Elytra with the grooves and ridges well defined and regular.
    *c*¹. Each elytron with seven regular narrow and continuous ridges, basal half with a broad smooth subsutural stripe, apical half with two short subsutural elliptical depressions with short ridges. **P. pinorum** Pascoe.
    *c*². Each elytron with seven continuous and two additional ridges in apical half only................ **P. pinorum** Pasc. var. **dimidiatus** Heller.
    *c*³. Elytra, the longitudinal ridges confluent in the middle with a more or less pronounced cross ridge. **P. pinorum** Pasc. var. **transversalis** Heller.
  *b*². Elytra with the grooves and ridges ill defined and irregular. The latter usually connected by cross ridges in the middle, the grooves broad with rather rudimentary secondary ridges. **P. dubiosus** Schultze.
*a*². Elytra without well-pronounced grooves or ridges, at most with obsolete traces, otherwise smooth, and with oblong shallow depressions or slightly depressed spots.
  *d*¹. Elytra in basal half with abbreviated stripelike shallow depressions beset with rudimentary scales, apical half with slightly depressed oblong spots.. **P. lacunosus** Heller.
  *d*². Elytra with small, oval, slightly impressed and well-defined grayish scale spots.. **P. tristis** Heller.
  *d*³. Elytra smooth and glossy with rather large and irregular dull spots. **P. consobrinus** Schultze.

Pachyrrhynchus pinorum Pascoe. Plate 2, fig. 11 (lateral view); Plate 4, fig. 11, ♀.

Pachyrrhynchus pinorum Pasc., Journ. Linn. Soc. London **11** (1873) 156; Heller, Abh. u. Ber. Königl. Zool. Anthr.-Ethnogr. Mus. Dresden 7 (1898–99) 6; Heller, Philip. Journ. Sci. § D 7 (1912) 306; Schultze, Philip. Journ. Sci. **16** (1920) 200.

Pachyrrhynchus pinorum var. *dimidiatus* Heller, Philip. Journ. Sci. § D 7 (1912) 306.

Pachyrrhynchus pinorum var. *transversalis* Heller, Philip. Journ. Sci. § D 7 (1912) 306.

Black, moderately glossy, elytra with alternating longitudinal grooves and ridges, the former beset with very fine grayish or white scales. Rostrum divergent toward apex, apical half scatteredly punctured, basal half with a well-pronounced triangular depression. Sides of rostrum beset with fine silver grayish hair, sides of head below eye with a small patch of white scales. Prothorax longer than broad, with an indistinct anterior submarginal groove. Dorsolaterally at the latter a small scale spot; another, also dorsolaterally, near the middle; and still another, more dorsally, at the posterior submarginal groove. Lateral margins with a larger scale patch. Elytra oblong-ovate, each elytron with ten longitudinal grooves and ridges, of which the first and second grooves are present only in apical half (= var. *dimidiatus* Heller), or the first two abbreviated grooves are interrupted by a cross ridge thus forming two oblong subsutural depressions (typical form). Mesosternum, metasternum, and first abdominal sternite with a spot laterally. Femora with a scale spot near apex. Penis structure, Plate 3, fig. 17.

Male, length, 17 to 18 millimeters (without rostrum); width, 6.2 to 6.5. Female, length, 15.5 to 20 millimeters (without rostrum); width, 6 to 8.

LUZON, Benguet Subprovince, Baguio (pine region); Mountain Trail between Baguio and rest house, near kilometer 88 (*McGregor; Curran; Taylor; Schultze*).

Pachyrrhynchus pinorum var. transversalis Heller. Plate 4, fig. 12, ♂.

Pachyrrhynchus pinorum var. *transversalis* HELLER, Philip. Journ. Sci. § D 7 (1912) 306.

The grooves on the elytra interrupted in the middle by a narrow or broad transverse smooth ridge.

Pachyrrhynchus pinorum Pascoe and the varieties *dimidiatus* and *transversalis* Heller are found together in the same localities, in the pine regions of Benguet Province, at altitudes of from 1,200 to 1,800 meters. On higher mountain ranges this species seems to be replaced by other nearly related species, such as *P. dubiosus* Schultze and *P. lacunosus* Heller. The fine white scales of *P. pinorum* are plainly visible only in very fresh specimens; I collected and examined hundreds of specimens in which the scales appear grayish or are almost invisible, due to a certain infiltration of greasy substances. The original description by Pascoe is as follows:

> Pachyrrhynchus pinorum. P. niger, nitidus, fere toto glaber; rostro apice tenuiter punctato, sulco transverso obsoleto, in medio fortiter triangulariter excavato; prothorace oblongo, utrinque rotundato, margine antico sulcato; elytris canaliculatis, canaliculis squamis concoloribus indistinctis indutis, interstitiis valde convexis, subtiliter transversim corrugatis, regione suturali postice maculis quatuor pupillato-impressis, 2 pone medium, 2 apicem versus obsitis, abdomine tenuiter transverse corrugato; tibiis intus subdenticulatis. Long. 9 lin.
>
> Hab. Luzon.

Pachyrrhynchus tristis Heller. Plate 2, fig. 13 (lateral view); Plate 8, fig. 11, ♂.

Pachyrrhynchus tristis HELLER, Philip. Journ. Sci. § D 7 (1912) 315.

Glossy black, prothorax and elytra with small grayish scale spots. Rostrum in apical half coarsely and scatteredly punctured, basal half with a strongly pronounced, triangular roundish depression beset with two small scale spots. Sides of head with a small spot below eye. Prothorax longer than broad with a rudimentary, indicated anterior submarginal groove. At anterior margin toward each side a small, and behind the middle another, larger, scale spot, still another larger spot at lateral margins. Elytra finely coriaceous with very faint and indistinct traces of longitudinal grooves, which are still more or less distinctly indicated near apex, in the male particularly a rudimentary fraction of the first groove and a swollen ridge being mostly present. Each elytron with two small oval scale spots near base and mostly four other spots in apical third. Penis structure, Plate 3, fig. 14.

Male, length, 17.8 millimeters (without rostrum); width 6.2. Female, length, 17.5 millimeters (without rostrum); width, 7.

LUZON, Benguet Subprovince; two specimens, which I obtained in exchange.

In its systematic position, this species is closely related to *P. lacunosus* Heller and *P. consobrinus* Schultze.

Pachyrrhynchus lacunosus Heller.

Pachyrrhynchus lacunosus HELLER, Philip. Journ. Sci. § D 7 (1912) 316.

Glossy black, elytra with broad but shallowly depressed longitudinal stripes and spots, beset with grayish scales. Rostrum in apical half finely and moderately densely punctured, basal half with a well-pronounced depression, front with a shallow depression bearing a patch of scales. Prothorax longer than broad, greatest width before the middle, very finely and scatteredly punctured. At anterior margin toward each side a large spot, another small roundish spot also toward each side near posterior margin, and a small oblong spot in the middle at lateral margin. Elytra with slight traces of puncture rows. An oblong subsutural and slightly depressed spot in the middle and another near apex. Another elongated marking in the second interstice reaching from base to middle and behind it another elongate spot. Fourth interstice at basal half and near apex with another oblong spot. A submarginal slightly depressed stripe mostly interrupted at the middle is continued near apex as a spotlike depression, the interstice at apex forming a strongly pronounced ridge.

Female, length, 18.5 millimeters (without rostrum); width, 7.6.

LUZON, Benguet Subprovince, Mount Pulogloko (*M. Ramos*).

Pachyrrhynchus dubiosus Schultze. Plate 7, fig. 7, ♀.

Pachyrrhynchus dubiosus SCHULTZE, Philip. Journ. Sci. 21 (1922) 574, pl. 3, fig. 4.

Black, elytra with broad somewhat irregular longitudinal furrows beset with very small grayish or nearly colorless scales. Rostrum toward apex strongly divergent, apical half scatteredly punctured, basal half with a strongly pronounced depression and medial groove. Prothorax longer than broad, finely punctate, a small patch of irregular coarser punctures located dorsolaterally near posterior margin. Elytra coriaceous. Each elytron with four broad furrows, the one next to lateral margin not so deep or so strongly depressed as the others. First and second furrows, for the entire length or less, third furrow only in apical half, with a narrow ridge. The furrows are more or less interrupted in the middle by cross connections of the prominent primary ridges or interstices. Another furrowlike depression in apical fourth and an oblong subsutural depression behind the middle and at apex. The interstices between the depressions in apical fourth are very strongly bulgingly pronounced. Femora with a coarse rugose patch on underside apically. Penis structure, Plate 3, fig. 13.

Male, length, 18 millimeters (without rostrum); width, 7. Female, length, 21 millimeters (without rostrum); width, 8.5.

LUZON, Benguet Subprovince, Mount Santo Tomas and Pauai (Haight's place) (*Schultze*).

Pachyrrhynchus consobrinus Schultze. Plate 2, fig. 12 (lateral view); Plate 9, fig. 7, ♀.

Pachyrrhynchus consobrinus SCHULTZE, Philip. Journ. Sci. 21 (1922) 574, pl. 2, fig. 5, ♂.

Glossy black, elytra with large dull and achromatic scale spots. Rostrum in apical half finely scatteredly punctured, basal half with a strongly pronounced triangular depression. Prothorax longer than broad, shiny black, very finely and scatteredly punctured, a small roundish spot toward each side near anterior margin, another behind the middle, and a large patch at lateral margins. Elytra in the male very oblong-ovate, in the female stouter in build; greatest width before the middle. A submarginal row of coarse punctures in apical half which becomes groovelike near apex. Each elytron with two large roundish dull grayish spots basally; three other large spots form a cross row before the middle and are usually more or less confluent. Another cross row of four spots in apical third and a large spot in apical triangle. Besides the above markings a sutural spot behind the middle and a large one at apex.

Male, length, 17.6 millimeters (without rostrum); width, 6.3. Female, length, 19 millimeters (without rostrum); width, 7.6.

LUZON, Bontoc Subprovince, Mount Polis (*Schultze*).

This species is related to *P. tristis* Heller.

GROUP XIV

This small group is typified by *Pachyrrhynchus amabilis* Schultze and contains only two species, the one just mentioned and *P. chamissoi* Schultze. Both species are characterized by having the general color of the head, prothorax, and legs in strong contrast to that of the elytra.

Key to the species of Pachyrrhynchus, Group XIV.

a^1. Elytra, the greater part densely beset with pale pinkish scales, the bare areas forming a large cross .... **P. amabilis Schultze.**
a^2. Elytra near the middle with a transverse row of white spots, or entirely bluish black (♂) .... **P. chamissoi Schultze.**

Pachyrrhynchus amabilis Schultze. Plate 2, fig. 6 (lateral view); Plate 7, fig. 13.

Pachyrrhynchus amabilis SCHULTZE, Deutsche Ent. Zeitschr. (1922) 38, pl. 1, fig. 10.

Head, prothorax, and legs except the tarsi very glossy glowing red. Antennæ, tarsi, and elytra very dark bluish green. The crossband on prothorax and the large scaled areas on elytra pale pink. Rostrum sparsely punctured in apical half, basal half with a rectangular depression and a longitudinal median groove. The depression bearing an oblong scale spot, another spot at sides of head. Prothorax as long as broad, very finely and scatteredly punctured, with a scale band along anterior margin and another along posterior margin, the latter discally somewhat denticulated. Both bands united at lateral margins. Elytra dull dark bluish green, with fine but very regular rows of punctures. Each elytron with a very large scaled area at basal half and another at apical half. These areas reach from about the first puncture row to side margin and are separated by a bare crossband in the middle. The bare areas on elytra form approximately a crosslike figure. Underside of mesothorax and metathorax laterally with a large scale spot.

Male, length, 14.5 millimeters (without rostrum); width, 6.

MINDANAO, Bukidnon Province, Lindabon (*Schultze*).

This is also a very strikingly colored and somewhat isolated species of the genus.

Pachyrrhynchus chamissoi Schultze. Plate 1, fig. 21, ♀ (lateral view); Plate 7, fig. 14, ♀; fig. 15, ♂.

Pachyrrhynchus chamissoi SCHULTZE, Deutsche Ent. Zeitschr. (1922) 39, pl. 1, fig. 9, ♀.

Head, prothorax, and legs glossy dark glowing red with a violet sheen. Antennæ, elytra, and tarsi bluish black. Rostrum divergent toward apex, basal half with strongly pronounced squarish depression, the lateral margins of which form prominent ridges which are transversely set off from front by a shallow cross groove in the male. The depression with a longitudinal median groove and an oblong scale spot, the latter mostly absent in the males. Prothorax as long as broad, finely punctured, with an indistinct anterior submarginal groove. Sides with two small irregular white scale spots in the female. Elytra dull, very finely coriaceous, each elytron with nine distinct and regular rows of punctures. In the female before the middle a cross row of larger or smaller white scale spots interrupted by the longitudinal rows of punctures. In apical third mostly an oblong and two small roundish spots. All the spots are variable and seem to be absent in the males. Mesothorax and metathorax laterally with a scale spot.

Male, length, 12 millimeters (without rostrum); width, 5. Female, length, 13.5 millimeters (without rostrum); width, 6.

MINDANAO, Bukidnon Province, Lindabon (*Schultze*).

On Plate 7, fig. 14, I have figured a female selected from a large series of specimens with extraordinarily and unusually large markings on the elytra.

GROUP XV

This group contains a number of species which are rather isolated from any of the other groups as well as among themselves. Included are the following: *Pachyrrhynchus argus*

Pascoe, *P. ochroplagiatus* Heller, *P. perpulcher* Waterh., *P. atrocyaneus* Schultze, *P. basilanus* Heller, and *P. croesus* R. Oberth.

Key to the species of Pachyrrhynchus, Group XV.

a^1. Medium to large.
  b^1. Elytra with large and strongly impressed creamy white ring spots. **P. argus** Pascoe.
  b^2. Elytra without impressed ring spots.
    c^1. Prothorax with scale markings.
      d^1. Prothorax with two brilliant golden green, dorsolateral spots at anterior and posterior margins. General color dark purplish red to black........ **P. perpulcher** Waterh.
      d^2. Prothorax with two small dorsolateral spots at anterior margin, and two large elongate dorsolateral spots in basal half, all spots light blue. General color dark bluish black. **P. croesus** R. Oberth.
    c^2. Prothorax without any scale markings. Elytra with twelve ochraceous spots........ **P. ochroplagiatus** Heller.
    c^3. Elytra with sixteen to eighteen spots. **P. ochroplagiatus** var. **multiplagiatus** var. nov.
a^2. Small.
  e^1. Elytra with a transverse brick red band in basal half. **P. basilanus** Heller.
  e^2. Elytra with ivory white spots........ **P. atrocyaneus** Schultze.

Pachyrrhynchus argus Pascoe. Plate 1, fig. 17, ♀ (lateral view); Plate 4, fig. 10.

Pachyrrhynchus argus PASCOE, Journ. Linn. Soc. London 11 (1873) 154, pl. 6, fig. 6; BEHR., Stett. Ent. Zeitg. (1887) 250; HEYDEN, Ber. Senkenb. Naturf. Ges. (1911) 84, pl. 1, fig. 2; HELLER, Philip. Journ. Sci. § D 7 (1912) 311.

Glossy black; prothorax and elytra with large impressed ring spots beset with creamy white scales. Rostrum in apical half scatteredly punctured, basal half with a strongly pronounced triangularly rounded depression. Front with two very small scale spots next to each eye and a spot on sides of head. Prothorax as long as broad, the sides slightly rounded, dorsolaterally two irregular ring spots and a smaller irregular ringlike figure at lateral margins. Elytra oblong-ovate, with twenty-four large ring spots, two of which are bifid sutural spots, one located slightly behind the middle, the other in apical fourth. Underside; mesosternum, metasternum, and first abdominal sternite with a spot laterally. Femora with a scale spot near apex. Penis structure, Plate 3, fig. 26.

Male, length, 13 to 15.5 millimeters (without rostrum); width, 5 to 6.8. Female, length, 14 to 18 millimeters (without rostrum); width, 6.2 to 7.8.

LUZON, Benguet Subprovince, Baguio; Mount Santo Tomas; Trinidad; Mountain Trail near rest houses at kilometers 30 and 88; Pauai (Haight's place); Mount Polis; Mount Pulog (*McGregor*; *Curran; Schultze*).

In fresh specimens the color markings are creamy or ivory white, in older examples ochraceous or pale brown. This species seems to be rather widely distributed over the mountain regions of northern Luzon at altitudes of from 1,500 to 2,800 meters.

Pachyrrhynchus ochroplagiatus Heller. Plate 4, fig. 9, ♀.

Pachyrrhynchus ochroplagiatus HELLER, Philip. Journ. Sci. § D 7 (1912) 311, pl. 2, fig. 11; SCHULTZE, Philip. Journ. Sci. 21 (1922) 593, pl. 3, fig. 6 (penis structure).

Glossy black; head and prothorax without spots, elytra with ochraceous scale spots. Rostrum, apical half irregularly punctured, basal half with a deep roundish depression, the dorsolateral edges swollen. Prothorax a little longer than broad, the sides slightly rounded, the greatest width before the middle nearer anterior margin, a small shallow depression laterad near posterior margin. Elytra impunctate, glossy. Each elytron with six ochraceous scale spots, two at base and four in apical half; of the latter, two are located dorsolaterally, one at margin and one at apex. Underside uniformly black. Penis structure, Plate 3, fig. 15.

Male, length, 15.5 millimeters (without rostrum); width, 7. Female, length, 17.5 millimeters (without rostrum); width, 7.7.

LUZON, Benguet Subprovince, Mount Pulog (*McGregor; Curran*). The specimens from the above locality show very little variation, but others received from Mount Lusong, Benguet (*M. Ramos*) are rather variable from the typical form in the number of spots on the elytra. This variation I designate—

Pachyrrhynchus ochroplagiatus var. **multiplagiatus** var. nov. Plate 1, fig. 18 (lateral view).

Each elytron with eight or nine spots, located as follows: Two at base, one small spot behind dorsal basal spot, and five in apical half, three of which form a cross row. Another specimen has an additional spot in the middle at outer margin.

Pachyrrhynchus perpulcher Waterh. Plate 1, fig. 23 (lateral view); Plate 9, fig. 1.

Pachyrrhynchus perpulcher WATERH., Proc. Ent. Soc. London (1841) 19; Ann. & Mag. Nat. Hist. 8 (1841) 218; Trans. Ent. Soc. London I 3 (1843) 312; SCHOENH., Gen. Curc. Suppl. 8 (1845) 382; HELLER, Philip. Journ. Sci. § D 7 (1912) 307, pl. 1, fig. 18.

Glossy black with a purplish sheen, prothorax and elytra with brilliant green, coppery, and bluish more or less ocellated scale spots. Rostrum in apical half scatteredly punctured, basal half with an oblong triangular depression extending to front, latter with an elongate scale spot. Sides of rostrum and head also with a scale patch. Prothorax broader than long, very finely and remotely punctate, with a roundish scale spot toward each side dorsolaterally at anterior margin and two others at posterior margin. Lateral margins with a broad scale patch. Elytra indistinctly punctate-striate. Each elytron with nine scale spots, two at base, two in the middle and two in apical third forming transverse rows; a smaller marginal spot is located at basal third, a large oblong marginal spot behind the middle, and a triangular spot near apex. Prosternum, mesosternum, and metasternum more or less closely beset with scales. Femora with an oblong scale spot in the middle and another near apex.

Male, length, 12 millimeters (without rostrum); width, 5.6. Female, length, 14 millimeters (without rostrum); width, 6.6.

LUZON, Kalinga Subprovince, Pinukpuk (*Herre*).

Among the material at my disposal this species was represented by only one old specimen labeled Luzon. Recently several specimens were collected by Doctor Herre at the above locality.

Pachyrrhynchus atrocyaneus Schultze. Plate 2, fig. 9, ♀ (lateral view); Plate 9, fig. 4, ♀.

Pachyrrhynchus atrocyaneus SCHULTZE, Deutsche Ent. Zeitschr. (1922) 40, pl. 1, fig. 12, ♀.

Glossy dark blue, prothorax and elytra with creamy white scale markings and spots. Rostrum in basal half with a strongly pronounced squarish depression. A scale spot on sides of head. Prothorax longer than broad, the greatest width before the middle, at base strongly constricted. A narrow scale stripe along anterior margin, continued at lateral margins, ending at posterior margin laterally, and a triangular spot dorsally at posterior submarginal groove. Elytra cordiform, with prominent longitudinal rows of large and uniform punctures, the interspaces between the puncture rows raised. Each elytron with nine small scale spots and a large oblong marginal patch in the middle. Two spots at base, three form a cross row at basal third, three others form another cross row at apical third, and one spot in apical triangle. Legs glossy brownish black.

Male, length, 9 millimeters (without rostrum); width, 3.8. Female, length, 12 millimeters (without rostrum); width, 5.

MINDANAO, Zamboanga Province, Zamboanga (*Schultze*).

This species seems to be rather isolated from other members of the genus.

Pachyrrhynchus basilanus Heller. Plate 8, fig. 13.

Pachyrrhynchus basilanus HELLER, Tijdschr. v. Ent. 66 (1923) 47, pl. 1, fig. 12.

Head and prothorax very dark bronze green, elytra black, slightly greenish glossy, with dull brick red scale markings. Rostrum with the dorsal depression slightly longer than broad. Prothorax with an anterior marginal scale band confluent with an elongate stripe at each lateral margin, dorsally at the base a triangular scale spot. Elytra strongly and regularly striate-punctate, apically somewhat prolonged. A broad transverse scale band at basal third and a large triangular scale patch at apical third. Metasternum and first abdominal sternite with a scale spot laterally. Legs also dark bronze green, except apical part of hind femora which is purplish.

Length, 11 millimeters; width, 5.

BASILAN (*C. F. Baker*).

This species I know mainly from Heller's description, although I saw the unique specimen in 1921 in Dresden; strange to say, Heller does not mention the oblong triangular dorsal scale spot on the prothorax in his description, though it is indicated in the figure. This species and *P. atrocyaneus* Schultze are somewhat isolated species of this genus which seem to represent more or less intermediate forms between this genus and *Sphenomorpha* Behrens, representatives of which are known only from the Moluccas and the New Guinea region. This species and *Doliops basilana* Heller[14] have a strong mimicry resemblance.

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[14] Tijdschr. v. Ent. 66 (1923) 45, pl. 1, fig. 9.

Pachyrrhynchus croesus R. Oberth. Plate 9, fig. 8.

> *Pachyrrhynchus croesus* R. OBERTH., Ann. Mus. Civ. Stor. Nat. Geneva 14 (1879) 570, pl. 1, fig. 2; BEHR., Stett. Ent. Zeitg. (1887) 254; HELLER, Philip. Journ. Sci. § D 7 (1912) 307, pl. 1, fig. 17.

Glossy bluish black, prothorax and elytra with light blue scale spots. Rostrum in basal half with a large triangular depression and medial groove. The depression separated from front by a cross groove. Front, sides of rostrum, and head below eye with a scale spot. Prothorax longer than broad, greatest width before the middle, very finely punctate, toward each side in basal half a large oblong scale spot. At anterior margin laterally a scale band and an oblong spot at lateral margins. Elytra very indistinctly striate-punctate, with twenty-two or twenty-four scale spots. Two or three spots located at base, of which the one next to lateral margin is oblong; four others form a cross row before the middle, the lateral marginal one of which is the largest and is directed backward; three other spots form another cross row in apical third, a triangular spot next apex, and a bifid sutural spot slightly behind middle. Underside, mesosternum, metasternum, and first and second abdominal sternites laterally with a large scale spot. Femora with a spot on underside next to apex.

Length, 18 to 21 millimeters (without rostrum); width, 7 to 7.5.

Moluccas, Sangir Island.

This species I know only from the descriptions.

ADDENDA

Some material was received too late to be included in its proper place.

To the notes on *Pachyrrhynchus orbifer* var. *inornatus* Waterh. and var. *circulifer* Chevr., Philip. Journ. Sci. 23 (1923) 640, add:

During November and December, 1923, my friend Mr. McGregor, while collecting in Ilocos Norte Province, paid special attention to observing and collecting the different forms of *P. orbifer*. At Bangui he found the form as shown in Plate 6, fig. 4, predominating but associated with a lesser number of forms of the var. *circulifer*, Plate 6, fig. 2, and intermediates, fig. 3; the forms were frequently collected together, in copula. In the vicinity of Solsona forms were collected which are very constant in the markings, the latter being similar to those shown in fig. 2 but much finer, or only indicated as traces. Specimens from around Piddig are about 90 per cent uniformly black, and only a few have faint markings like those from the former locality.

After the description of P. *erichsoni eschscholtzi*, Philip. Journ. Sci. 23 (1923) 665, add:

Pachyrrhynchus erichsoni eschscholtzi var. **ilocanus** var. nov.

Black; head, prothorax, and legs very glossy. Elytra with the puncture rows very faintly indicated. All spots consisting of rather brilliant violet scales. Each elytron with ten spots; two near the base, three form an irregular transverse row at the middle, one behind the middle at the lateral margin, three form a cross row at the apical third, and one near the apex.

LUZON, Ilocos Norte Province, Bangui (*McGregor*).

This interesting local variety from northern Luzon enlarges still more the distribution range of *P. erichsoni*, although the latter already holds the record for the relatively widest distribution.

The description of a new species, here given, should follow the description of *P. semperi:*

Pachyrrhynchus negrosensis sp. nov.

Very glossy black, with narrow pale reddish scale stripes. The markings very similar to those in *P. semperi* Heller. Rostrum in basal half strongly depressed, with a well-pronounced medial groove and a bifid scale spot. The groove not extending to the front, the latter finely and scatteredly punctured. Sides of head with a scale spot below eye. Prothorax relatively small, as long as broad, sides very slightly rounded, with a narrow irregular anterior submarginal band confluent with a broader stripe at each lateral margin. Along the posterior margin some scattered scales, and dorsolaterally in the basal half an abbreviated stripe. Elytra similar in form to those of *P. stellio* Heller, finely but regularly striate-punctate, the punctures coarser toward apex. Basal half in the third interstice with an abbreviated longitudinal stripe not quite reaching the narrow transverse band before the middle, but confluent at the base with an irregular submarginal stripe. The latter is shortly interrupted near apex and terminates as an elongate subapical spot. Each elytron furthermore in apical half with three short abbreviated stripes in the third, fifth, and seventh interstices, and an elongate subsutural dash near apex. Prosternum, mesosternum, and metasternum beset with scattered scales. Femora with a subapical band of scattered scales. Tibiæ relatively slender and long.

Male, length, 12.5 millimeters (without rostrum); width, 5.8.

NEGROS, Occidental Negros Province, Cuernos Mountains, 1,800 meters (*J. W. Chapman*).

This species has a strong superficial resemblance to *P. semperi* Heller but is much smaller; furthermore, in the latter species the rostrum is different and the prothorax is longer than broad. *Pachyrrhynchus negrosensis* is to be placed under Group X as follows:

b^3. Each elytron in the apical half with three abbreviated longitudinal stripes .... P. negrosensis sp. nov.

ILLUSTRATIONS

[Original colored drawings, except Plate 8, by W. Schultze; drawings of Plate 8, by Max Böhme. All figures enlarged about × 1.5.]

PLATE 7

FIG. 1. *Pachyrrhynchus sulphureomaculatus* Schultze, female. Mindanao, Cotabato, Cotabato.

2. *Pachyrrhynchus benguetanus* sp. nov., male. Luzon, Benguet.

3. *Pachyrrhynchus gemmatus* subsp. *purpureus* Kraatz, female. Luzon, Cagayan, Sanchez Mira.

4. *Pachyrrhynchus sarcitis* Behr., female. Calayan Island.

5. *Pachyrrhynchus confusus* Schultze, female. Luzon, Laguna, Los Baños.

6. *Pachyrrhynchus viridans* Heller, female. Calayan Island.

7. *Pachyrrhynchus dubiosus* Schultze, female. Luzon, Benguet, Mount Santo Tomas.

8. *Pachyrrhynchus chlorites* Chevr., female. Calayan Island.

9. *Pachyrrhynchus apicatus* Schultze, female. Polillo Island.

10. *Pachyrrhynchus venustus* Waterh., female. Mindanao, Surigao, Surigao.

11. *Pachyrrhynchus taylori* Schultze, female. Luzon, Kalinga, Balbalan.

12. *Pachyrrhynchus taylori* subsp. *metallescens* subsp. nov., male. Luzon, Ifugao, Polis Pass.

13. *Pachyrrhynchus amabilis* Schultze, female. Mindanao, Bukidnon, Lindabon.

14. *Pachyrrhynchus chamissoi* Schultze, female. Mindanao, Bukidnon, Lindabon.

15. *Pachyrrhynchus chamissoi* Schultze, male. Mindanao, Bukidnon, Lindabon.

16. *Pachyrrhynchus rufopunctatus* Waterh., male. Polillo Island.

PLATE 8

FIG. 1. *Pachyrrhynchus psittacinus* Heller. Luzon, Bataan, Lamao.

2. *Pachyrrhynchus lorquini* Chevr. Luzon, Laguna.

3. *Pachyrrhynchus eques* Heller. Luzon, Cagayan, Abulog River.

4. *Pachyrrhynchus congestus* subsp. *pavonius* Heller, female. Luzon, Nueva Vizcaya, Imugan.

5. *Pachyrrhynchus pulchellus* var. *bakeri* Heller, female. Luzon, Benguet, Baguio.

6. *Pachyrrhynchus infernalis* Fairm. Yayoyama, Ishigaki-shima.

7. *Pachyrrhynchus psittaculus* Heller.

8. *Pachyrrhynchus forsteni* Vollh., female. Ternate.

9. *Pachyrryhnchus morotaiensis* Vollh. Halmahera.

FIG. 10. *Pachyrrhynchus möllendorffi* Heller.
11. *Pachyrrhynchus tristis* Heller, male. Luzon.
12. *Pachyrrhynchus nobilis* Heller.
13. *Pachyrrhynchus basilanus* Heller. Basilan.
14. *Pachyrrhynchus semperi* Heller.
15. *Pachyrrhynchus dohrni* Behr., female.
16. *Pachyrrhynchus helleri* Kuntzen, female. Luzon.

PLATE 9

FIG. 1. *Pachyrrhynchus perpulcher* Waterh., female. Luzon.
2. *Pachyrrhynchus signaticollis* Schultze, male. Mindanao, Agusan, Agusan River.
3. *Pachyrrhynchus apocyrtoides* Schultze, male. Mindanao, Bukidnon, Lindabon.
4. *Pachyrrhynchus atrocyaneus* Schultze, female. Mindanao, Zamboanga.
5. *Pachyrrhynchus libucanus* sp. nov., male. Libucan Island near Samar.
6. *Pachyrrhynchus smaragdinus* Behrens.
7. *Pachyrrhynchus consobrinus* Schultze, female. Luzon, Bontoc.
8. *Pachyrrhynchus croesus* Oberth. Sangir Island.
9. *Pachyrrhynchus halconensis* Schultze, female. Mindoro, Mount Halcon.
10. *Pachyrrhynchus morio* Heller, male. Luzon, Benguet, Mount Lusong.
11. *Pachyrrhynchus roseomaculatus* Waterh., male. Luzon?
12. *Pachyrrhynchus semiignitus* Schultze, male. Mindanao, Cotabato, Pikit.
13. *Pachyrrhynchus pseudoproteus* Schultze. Luzon, Laguna.
14. *Pachyrrhynchus regius* Schultze, male. Leyte, Cabalian.
15. *Pachyrrhynchus erichsoni* Waterh., male. Dinagat Island.
16. *Pachyrrhynchus schönherri* Waterh., female. Cotype from British Museum.
17. *Pachyrrhynchus latifasciatus* Waterh., male. Cotype from British Museum.
18. *Pachyrrhynchus samarensis* sp. nov. Samar, Catarman.
19. *Pachyrrhynchus cumingi* var. *boholensis* var. nov., female. Bohol, Bilar.

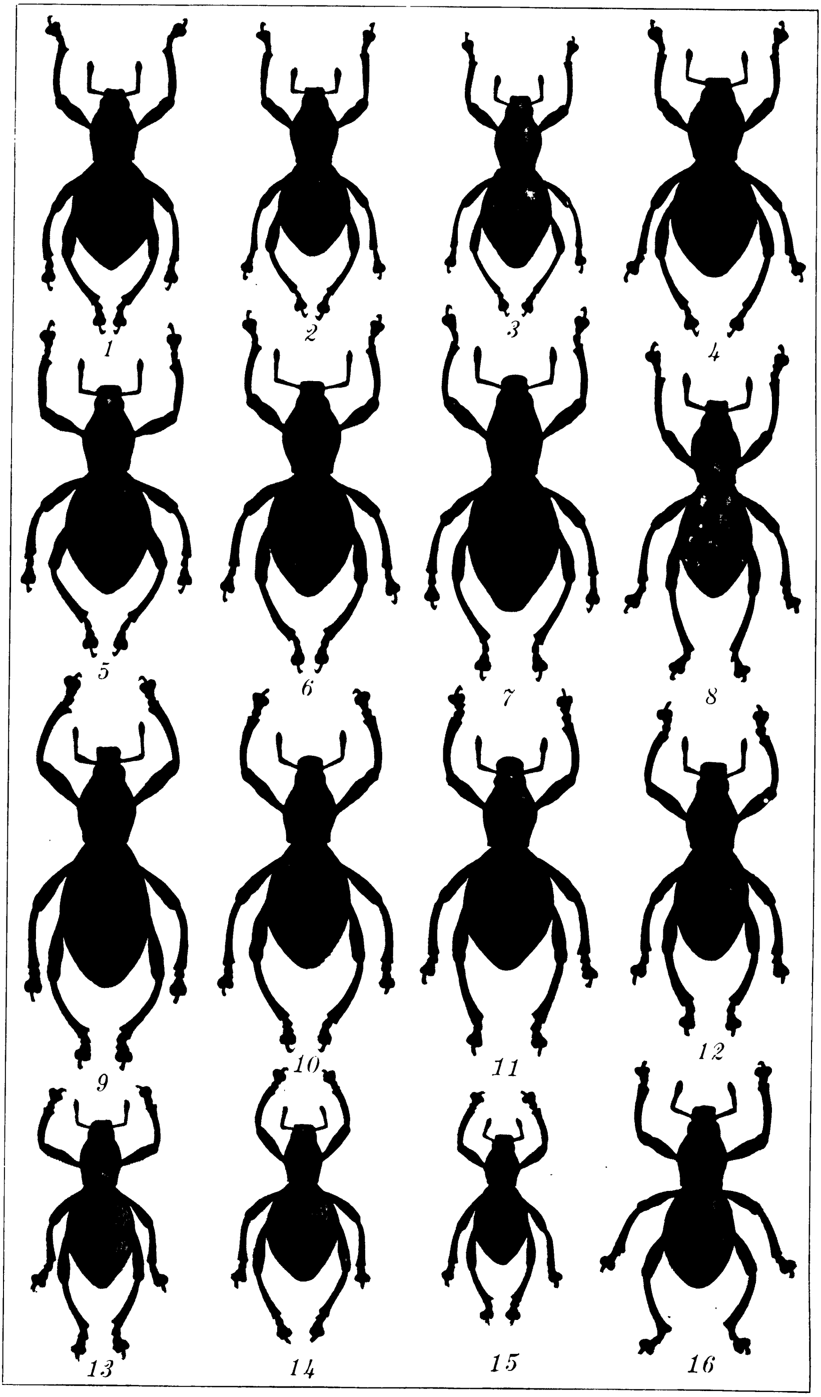

PLATE 7.

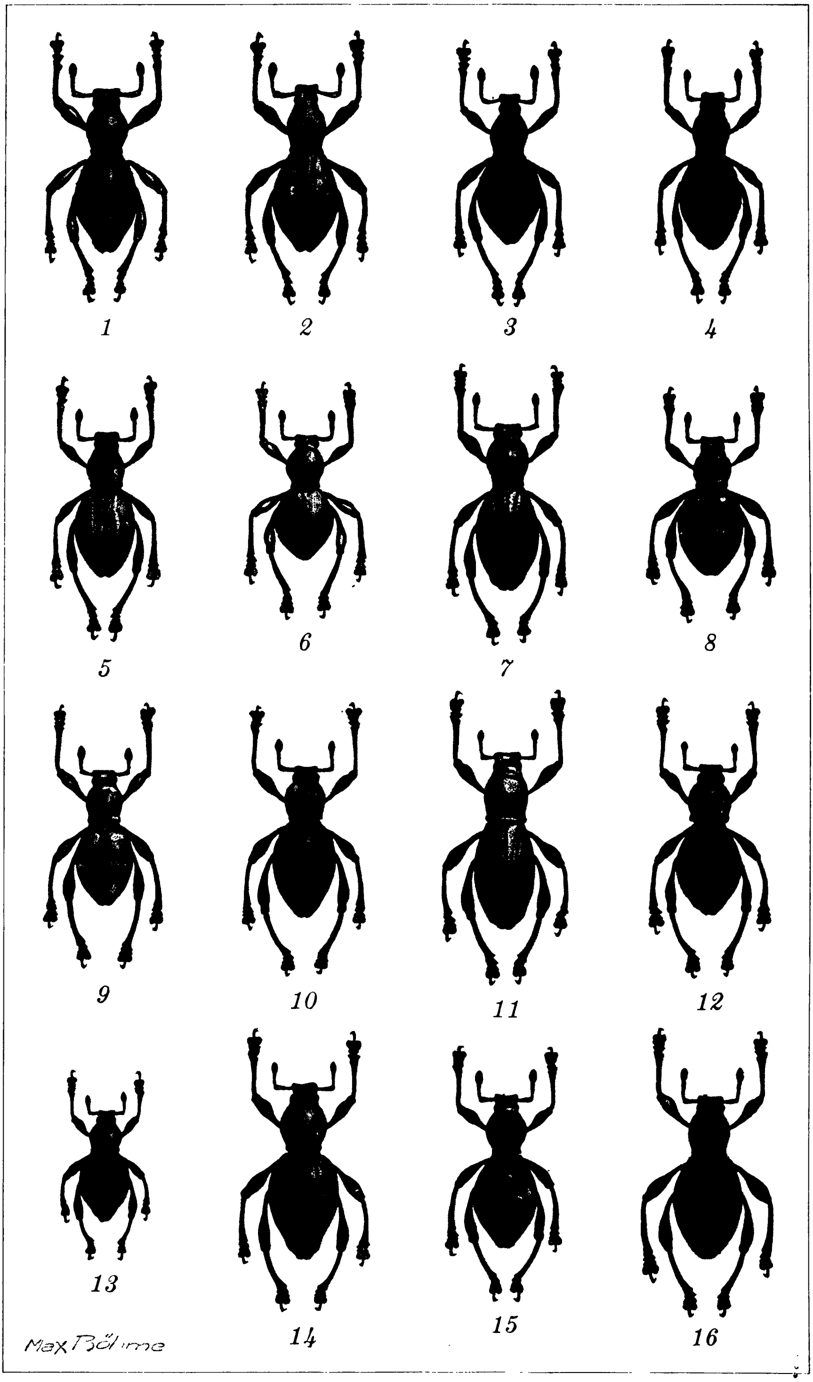

PLATE 8.

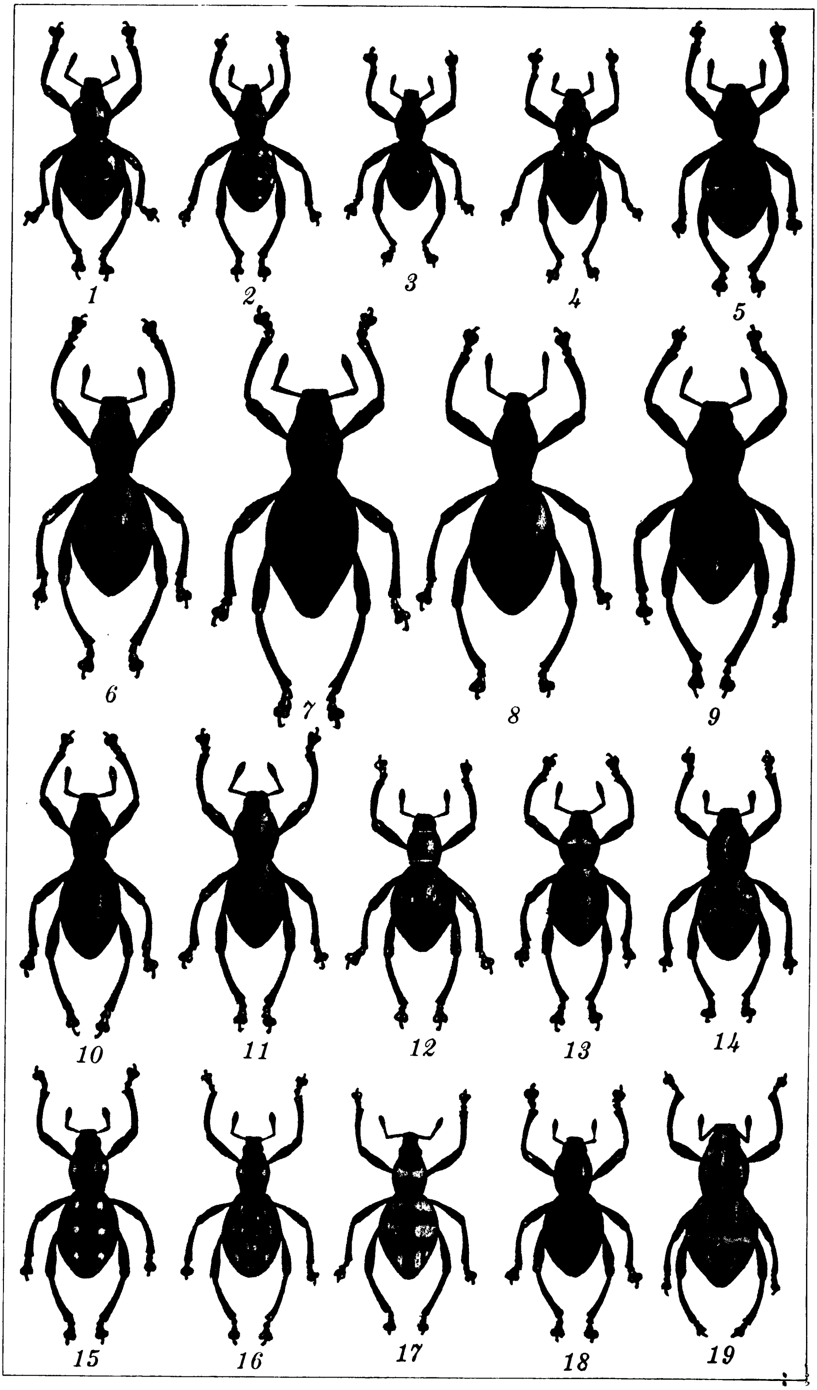

PLATE 9.

NOMENCLATORIAL NOTES ON THE JASSOIDEA

By C. F. BAKER

Dean, College of Agriculture, University of the Philippines

The following repetitions of names in the Jassoidea require renaming, in connection with the preparation of a list of the jassoid insects of the world. No record is at hand showing that these changes have yet been made and hence the following new names are suggested:

Penthimia distanti nom. nov. for *P. nitida* Distant 1912, not Lethierry 1877.

Goniozygum (Goniognathus) appellans nom. nov. for *G. obesus* Distant 1918, not Jacobi 1910.

Deltocephalus deletus nom. nov. for *D. thoracicus* Distant 1908, not Fieber 1869.

Scaphoideus ineffectus nom. nov. for *S. tessellatus* Distant 1917, not Osborn 1909.

Thamnotettix montivagus nom. nov. for *T. montanus* Matsumura 1914, not Van Duzee 1892.

Thamnotettix placatus nom. nov. for *T. placidus* Osb. 1905, not Horvath 1897.

Idiocerus kirschbaumi nom. nov. for *I. cupreus* Kirschbaum 1868, not Walker 1851.

Idiocerus incertus nom. nov. for *Idiocerus maculatus* Distant 1912, not Melichar 1896.

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A BIOCHEMICAL STUDY OF RESISTANCE TO MILDEW IN OENOTHERA[1]

By JOAQUIN M. MARAÑON
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[1] From the Laboratory of Plant Chemistry of the Department of Botany, University of Michigan, Ann Arbor, Michigan. This work was undertaken at the suggestion and under the direction of Prof. H. H. Bartlett, to whom I desire to express my indebtedness for his ever-ready help and invaluable advice during the progress of the work. I wish also to express my appreciation for assistance rendered by Dr. Frieda Cobb-Blanchard in the preparation of the record of the parentage of the plants that I examined, and to Mr. Peter J. Klaphaak for permitting me to use his *Oenothera* cultures and his field notes on them.

INTRODUCTION

THE NEED OF BIOCHEMICAL DATA IN THE SOLUTION OF THE PROBLEM OF IMMUNITY AND SUSCEPTIBILITY TO DISEASE IN PLANTS

The researches of recent years on the physiology of parasitism prove the ever-increasing need of biochemical data in the solution of the complex causes of immunity to disease in plants [see Appel(2) and Butler(8)]. Thus, Ward,(50) after having reviewed the literature dealing with the parasitism of fungi from the time that De Barry, Pringsheim, Koch, and Pasteur established the foundation of the parasite or germ theory of disease, reviews his own work on the Uredineae and makes the following statement regarding the conditions of parasitism in this group:

> Infection, and resistance to infection, depend on the power of the fungus protoplasm to overcome the resistance of the cells of the host by means of enzymes or toxins; and reciprocally, on that of the protoplasm of the cells of the host to form antibodies which destroy such enzymes or toxins, or to excrete chemotactic substances which repel or attract the fungus protoplasm.

Massee(31) holds the opinion that—

> the entrance of the germ tubes of a parasitic fungus into the tissues of a living, healthy plant depends on the presence of some substances, in the cells of the host, attractive to the fungus. In other words, infection is due to positive chemotaxis.

Wagner(49) indorses the view of Ward, saying that in some healthy plants three classes of antibacterial products are formed; namely, agglutinin, lysin, and substances limiting the multiplication of spores and bacteria.

Cook(12) reports that the loss of resistance to the attack of fungi shown by certain fruits after they have been removed from the trees is correlated with a decrease of enzymatic activity. Further, in collaboration with Wilson(14) he observes the toxic action of tannins and vegetable acids on the germinating spores of *Endothia parasitica* and related species.

Mains(30) indicates the close relationship of rust infection to the carbon metabolism of the host plant when he observes that, in the absence of light, the rust *Puccinia sorghi* is not able to develop in corn seedlings or pieces of corn leaf which have been deprived of their soluble carbohydrates. He, therefore, suggests that the obligate parasitism of the rusts is perhaps due to their requirement of particular organic compounds contained in the living host.

Gustafson(19) finds that the respiration of *Penicillium chrysogenum* increases up to a certain point with the increase of the hydrogen ion concentration of the medium and that the hydroxyl ion greatly inhibits respiration.

Hawkins and Harvey(21) observe that *Pythium debaryanum* Hesse secretes an enzyme that dissolves the middle lamella of the host tissues, and a toxin that kills the cells of the potato tuber; but nonchemical factors are also concerned with infection, for by a mechanical device these experimenters were able to prove that more pressure is required to puncture the tissues of the fairly resistant strains of the tuber than is required for the susceptible ones. More recently, Brown(7) reports that certain volatile substances given off from plant tissues have a distinct effect on the germination of the spores of *Botrytis cinerea*, some having a stimulating and others a retarding effect. He also obtained similar results by using ethyl acetate and various essential oils.

In another direction, where the specificity of plant pathogens in relation to their hosts is involved, we find Reed(40) pointing out the physiological specialization of parasitic fungi, and Thomas(48) presenting data to show that infection of *Apium graveolens* by *Septoria apii* is favored by conditions which accelerate the growth of the host. Raines,(39) in experimental work on certain rust diseases of the higher plants, concludes that the vegetative vigor of the host is a factor which influences its susceptibility and resistance to rusts. Allen,(1) as a result of her recent cytological studies of the infection of resistant and susceptible wheats by *Puccinia graminis tritici*, confirms the hypothesis that "immunity is due to definite antagonistic chemical interactions between host and parasite."

These various experimental findings are of extreme importance in the biochemical consideration of disease resistance. They prove two important points; first, the existence of particular chemical substances in plants which may be either toxic or stimulative to parasitic fungi and, second, the dependence of parasitic fungi upon specific biochemical conditions within their hosts. From a biochemical standpoint it is not hard to understand how certain highly specialized fungi are restricted to particular hosts, because only those hosts provide the special compounds used in their nutrition, or perhaps because only certain ones among a narrow range of possible hosts fail to secrete inhibiting substances when infection takes place.

Some very significant results have already been obtained in the biochemical study of immunity in plants, as may be seen from the extensive literature reviewed by Willaman and Sandstrom(51) coincidently with the publication of their own investigations on the biochemistry of plant diseases.

Jones(25) found cabbage to be resistant or nonresistant to the attacks of *Fusarium conglutinans;* Peltier(37) found wild relatives of the cultivated citrus fruits immune to citrus canker; Christensen(9) demonstrated the resistance of certain varieties of swede to *Plasmodiophora brassicae;* and Norton(34) developed strains of asparagus resistant to *Puccinia asparagi.*

Turning to the powdery mildews, Salmon (42, 43) found striking contrasts in the resistance of various species of *Hordeum* and of the genus *Bromus.* Klaphaak and Bartlett(27) found the same situation in strains and hybrids of *Oenothera* which are often the hosts of mildew strains referred to *Erysiphe polygoni* DC. It was the material of crosses prepared especially for the last-mentioned investigation that was made available to me.

THE OBJECT OF THE INVESTIGATION

This investigation concerns the problem of resistance to mildew in the genus *Oenothera.* The chemical compositions of several resistant and susceptible strains were compared, in order to discover whether or not there were definite correlation between composition and reaction to mildew. It was recognized, of course, that immunity might have a true biochemical basis, even if the gross analytical data failed to show differences. The power of a plant to secrete antibodies would not, for example, be indicated by such analytical work as that undertaken in the present investigation. If, on the contrary, there were large differences in the concentration of soluble carbohydrates or nitrogenous constituents, of such a nature as to have some obvious relationship to the nutrition of the fungus, the results would be of value. Again, differences in acidity, in the concentration of tannin, or of inorganic constituents, might be interpreted, if found, as a basis for corresponding differences in resistance. It was suspected, of course, when this investigation was undertaken, that such differences in gross chemical composition would be found. Whether they were or not, however, the analytical data would still be valuable for the light they would throw on the inheritance of chemical characteristics, on the fluctuating variation in chemical composition of the same strain from year to year, and on the correlation between chemical composition and morphological characteristics of the several strains. The material was chosen so that the results would throw light on some of these matters, even if the chemical basis for disease resistance should not be disclosed.

THE ADAPTABILITY OF OENOTHERA FOR BIOCHEMICAL STUDIES OF DISEASE RESISTANCE

The choice of *Oenothera* for the investigation was determined not only by the sharp distinctions in disease resistance shown by the various strains, but also by the fact that there was available a great deal of genetically known material. Furthermore, the results would fit into a large body of genetical data regarding the same material and the usefulness of the results would thereby be enhanced. It was by no means necessary to use *Oenothera,* however, for strains differing with regard to disease resistance are found in most groups of plants.

It was possible to secure samples of resistant and susceptible *Oenothera* strains grown under identical conditions and collected at the same time, and thus to reduce to a minimum the possible effects of external factors. Klaphaak and Bartlett(27) noticed that—

> nothing is more characteristic of the various elementary species and hybrids than the great differences that they show in susceptibility to infection by mildew. * * * the differences shown by certain pairs of reciprocal hybrids, were astonishingly definite, the one being white with mildew and the other absolutely free, although both were grown in adjoining rows under identical conditions, and often with interlocking branches.

Moreover, in *Oenothera,* resistant strains or susceptible ones may be obtained at will, since resistance is inherited as a unit factor, and the rules governing the inheritance of the factor have been worked out for several strains in accordance with the hypothesis of heterogametism put forward by Bartlett(5) and by Cobb and Bartlett.(10) The experimental findings with regard to mildew resistance conform exactly to theoretical expectations and justify the zygotic formulae assigned to the strains by Klaphaak and Bartlett. It is not deemed necessary to explain here how immunity and susceptibility in *Oenothera* are formulated on the basis of this hypothesis, since such information has been published in the papers referred to. For the same reason I have omitted the descriptions of the morphological external characters of the elementary species and hybrids that I used for my experiments, as well as discussions of the mildew which infects them, since such data are either on record already, or soon will be through the publications of co-workers.

It may be said, however, that in the strains which I have grown for my studies I noted that, in some cases of reciprocal hybrids, the mildewed one is vegetatively more vigorous than the resistant one. On the other hand, the leaves of the resistant hybrid are darker green and tougher than the susceptible one. It might seem offhand that the differences in susceptibility and immunity could be accounted for by some morphological characters of the forms, but Klaphaak and Bartlett,(27) after examination of sections of leaves from the five different species and hybrids chosen, stated that no such morphological differences of the leaves could be detected. Salmon,(42) in his studies of the barley mildew, *Erysiphe graminis* DC., presumably did not find any morphological differences of the host plant that would explain resistance, since he stated that "susceptibility and immunity were due to constitutional (physiological) peculiarities and not to any structural ones." De Istvanffi and Palinkas,(16) in their pathological studies of the vine mildew, *Plasmopara viticola*, express the opinion that—

> the susceptibility of the plant depends upon the supply of water in the organ, the vapour tension in the stomatic chambers and intercellular cavities generally, the turgescence of the cells, and to some extent on the chemical composition of the cell sap.

In view of these facts, the conclusion seems warranted that the resistance to infection by powdery mildew shown by a number of plants must have a physiological or biochemical explanation.

SOME PREVIOUS RESEARCHES BEARING ON THE PROBLEM

There has been no previous work, so far as I am aware, that deals with the biochemistry of resistance and susceptibility to any form of powdery mildew. Three papers which concern various aspects of the mildew problem are of interest in this connection. These are by Spinks,(46) Montemartini,(33) and Laurent.(28)

Spinks studied the effects of some inorganic salts on susceptibility of barley to mildew (*Erysiphe graminis*), and of wheat to yellow rust (*Puccinia glumarum*). He grew resistant and susceptible varieties of these two plants in Detmer's nutrient solution, with varying amounts of different salts. He concluded (*a*) that when the plants were provided with a large amount of nitrogen either in the form of ammonium salts or nitrate, their susceptibility was increased, (*b*) that with lithium salts and mineral manures, especially the ones rich in potash, susceptibility was reduced, and (*c*) that plants which were semistarved with respect to nitrogen exhibited a considerable degree of immunity. Since Spinks's object was not strictly biochemical, he did not determine the amount of the different salts absorbed by the plants, or what became of the salts after they were absorbed. His findings, however, indicate the relationship of the nitrogen nutrition of the host plant to its susceptibility to the disease.

The relation of the nitrogenous constituents of the plant to mildew infection was also noted by Montemartini.(33) He observed that the water-soluble nitrogen in the leaves of the varieties of American oak resistant to powdery mildew constitutes only a little over 0.1 of the total nitrogen in the leaves. He said that this confirmed the previously published report of Pantanelli(35) that, in the susceptible oaks, the soluble nitrogen represents from 0.4 to 0.7 of the total nitrogen, while in resistant oaks it does not exceed 0.3.

Laurent(28) reported that severe infection of grapevines was noticed in the vineyards which had been manured directly with farmyard manure in the same year that the infection occurred, whereas in the ones in which phosphate and potassium fertilizers were used, infection was considerably reduced. Resistance was also found to vary according to the method of pruning and nipping, and the nature of the stock. He considered, therefore, that "all these factors act indirectly by modifying the chemical and physical qualities of the vine cells, resistance being due to the increase of the concentration of the vine-sap."

The strains of *Oenothera* used in the investigation are listed in Table 1.

MATERIAL

TABLE 1.—*List of elementary species and hybrids studied.*

Key No.	Culture No.	Name of strain.	Characteristic of strain.
1	0847	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant.
1a	1827		
1b	2960		
2	0822	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible.
2a	1824		
2b	2959		
3	0864	*Oe. pratincola* hyb. *immunis*	Resistant.
3a	1826		
3b	2956		

TABLE 1.—*List of elementary species and hybrids studied*—Continued.

Key No.	Culture No.	Name of strain.	Characteristic of Strain.
4	0823	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible.
4a	1825		
4b	2954		
5	0830	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis*	Resistant.
5a	1804		
6	0820	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis*	Susceptible.
6a	1805		
7	0829	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis*	Do.
8	1818	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant.
8a	2966		
9	1819	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible.
9a	2963		
10	0838	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis*	Resistant.
11	0821	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago"*	Susceptible.
12	0814	*Oe. cinerescens* × *Oe. mississippiensis*	Resistant.
13	0827	*Oe. mississippiensis* × *Oe. cinerescens*	Susceptible.
13a	1800		
13b	2957		
14	1802	*Oe. cinerescens* × *Oe. mississippiensis* (metaclinic hybrid)	Do.
14a	2958		
15	0299	*Oe. pratincola* × *Oe. reynoldsii* (*Oe. pratincola* hyb. *amycosa*)	Resistant.
16	0177	*Oe. reynoldsii* × *Oe. pratincola*	Susceptible.
17	0842	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*	Do.
17a	1816		
17b	2962		
18	0849	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago"*	Do.
18a	1817		
18b	2961		
19	0831	*Oe. mississippiensis* × *Oe. "biennis Chicago"*	Do.
19a	1806		
20	0841	*Oe. "biennis Chicago"* × *Oe. mississippiensis*	Do.
21	0839	*Oe. "biennis Chicago"* × *Oe. mississippiensis*	Do.
21a	1807		
22	0833	*Oe. mississippiensis* × *Oe. pratincola* hyb. *rubricalyx*	Do.
22a	1810		
23	0848	*Oe. pratincola* hyb. *rubricalyx* × *Oe. mississippiensis*	Do.
23a	1811		
24	1346	*Oe. pratincola* mut. *nitidissima*	Resistant.
24a	1348	*Oe. pratincola* mut. *nitidissima*	Do.
25	1347	*Oe. pratincola* mut. *nitidissima*	Susceptible.
25a	1349	*Oe. pratincola* mut. *nitidissima*	Do.
26	199	*Oe. numismatica*	Resistant.
27	1191	*Oe. pratincola* mut. *simulans*	Do.
28	1192	*Oe. pratincola* mut. *simulans rubricalyx*	Susceptible.
29	1829	*Oe. pratincola* hyb. *immunis*	Resistant.
29a	2953		
30	1231	*Oe. reynoldsii* × *Oe. pratincola*	Do.
31	167	*Oe. pratincola*	Susceptible.
32	1828	*Oe. mississippiensis*	Do.
33	1234	*Oe. reynoldsii*	Resistant.
34	2952	*Oe. pratincola* hyb. *rubricalyx*	Susceptible.
35	2950	*Oe. "biennis Chicago"*	Do.

COLLECTION OF MATERIAL

In all my experiments the leaves only were analyzed, because they are the parts of the plant which are most severely attacked by the mildew, and are mildewed earlier in the season than the stems. There seemed no object in carrying all the work through in parallel with stems, since the large amount of woody tissue would render variation in soluble constituents less easily detectable.

The first year's collection was made during the early part of September, 1920. Some of the leaves of the cultures had already shown signs of chlorophyll degradation, but the mildew could still be seen on the leaves of the susceptible strains. Since this was the time when the problem was planned, I decided to get the materials that were available and use them for finding out whether or not chemical differences between resistant and nonresistant leaves persisted. The data were, of course, only to be used as amplified by material of the following year, collected earlier in the season.

Individual plants of all strains selected during the first year were self-pollinated, and their progenies were grown in 1921. Leaves were again collected, but this time they were picked during the middle part of August, the period when the plants were observed to be in the developmental stage and when the mildew was most active. In this year I also collected leaves from some strains not represented in my first year's collection, for purposes that will be explained later on. In the third year, 1922, the cultures were confined to five pairs of reciprocal hybrids which were self-pollinated in 1921, and to three elementary species. The five pairs of reciprocal hybrids were the ones that had provided the best material during the first two years, while the three elementary species were genetically the same as the parents of the three pairs of reciprocal hybrids. The first year's analyses were made of hybrids already in the garden when the work was planned. The parents had been grown the year before. For complete data it was necessary to analyze material believed to be morphologically and genetically identical with the actual parents of the hybrids. Such strains had been carried on in the garden cultures, and provided material for analysis in the third year of the experiment after it had been conclusively shown that year after year the various strains maintain their chemical characteristics with the same fidelity that they maintain their morphological ones.

Two separate collections of leaves were made this time (1922), the first one from July 5 to July 19 when the susceptible strains were not yet infected by the mildew, and the second one from August 23 to August 31 when the susceptible strains were heavily infected.

The leaves were picked one by one from the main stems and branches of the plants and care was taken that a fairly representative portion of the full-grown leaves of each plant was collected, and that those plants in the cultures which appeared to be phenotypically different from the rest (twins or mutations) were left untouched. The number of individual plants in a culture representing one strain varied from one hundred to three hundred, and the leaves collected from all of them were mixed and rapidly dried in the sun. The dried leaves were placed in clean cardboard boxes and stored temporarily until they could be ground. They were milled to pass an 80-mesh sieve. The fine powder was then kept in dry glass jars. To make the material as comparable as possible, reciprocal hybrids were collected the same day, between 9 o'clock in the morning and 6 o'clock in the evening. It was not found necessary to brush the leaves for the purpose of removing any sand that might adhere to their surfaces for, since they were picked one by one, it was possible to avoid taking those which were not free from particles of foreign matter.

PLAN OF THE INVESTIGATION

The strains used can for convenience be considered in five groups (see Table 1). The first group contains the twelve strains and elementary species that were the parents of the reciprocal hybrids. The second group consists of seven pairs of reciprocal hybrids in which one hybrid of each reciprocal pair is resistant and the other one is susceptible. The third group is made up of three pairs in which both reciprocal hybrids are susceptible. The fourth consists of four strains of a single mutation, two of the four susceptible and the other two resistant. The fifth is composed of pairs of strains that have the same genetic composition but different pedigrees. These different groups of strains were used in order to answer the following questions: (*a*) Is there any difference in chemical composition between the resistant and susceptible strains of *Oenothera?* (*b*) If so, is there the same contrast in the chemical composition between reciprocal hybrids unlike in resistance to mildew that there is between wild elementary species of unlike resistance? (*c*)

In cases of mutations arising from the same parents and differing from one another with regard to resistance and susceptibility, are the visible differences between the forms paralleled in the chemical characteristics? (*d*) How does the chemical composition of their parents compare with that of hybrid progenies? (*e*) If two strains are judged by morphology and breeding behavior to have the same genetic composition, will they have also the same chemical composition?

Biochemical data bearing upon these five points were all desirable before any deduction could be made as to whether or not a chemical basis for resistance and susceptibility could be detected by the usual procedure of chemical analysis. It was planned to confine the investigation to the quantitative determination of the well-known chemical constituents of the plants, leaving for future consideration the study of specific constituents, if such there seemed to be. In order to reduce the analytical work, only four pairs of reciprocal hybrids were used in the study of the nitrogen distribution, the determination of carbohydrates, and the ash analysis.

Before proceeding to the description of the analytical methods adopted, I should explain why the study of the dried leaves was not supplemented by parallel investigations of the juices from the fresh plants. The juices were found to be so mucilaginous that the mechanical difficulties of obtaining sufficient material would have been almost insuperable in the case of an extensive investigation covering a large variety of strains. It seemed more logical to examine the tissues as a whole, leaving to the future more detailed researches, if the preliminary survey should indicate promising points of attack. More refined methods could be applied to more restricted material—perhaps a single contrasting pair of mutations or reciprocal hybrids, or a parent species and one of its mutations.

I am aware that during the process of drying there might have occurred autolytic changes which alter the chemical composition of the leaves. Since, however, the leaves were collected during summer days, they could be rapidly dried in one day so as to reduce autolysis to a minimum. Furthermore, since the experimental results were intended for comparative study any modification of the constituents of the leaves by autolysis would presumably be more or less of the same magnitude in all strains, because all the leaves were dried in the same way. Parkin(36) has studied autolytic changes in the composition of leaves during drying in connection with his studies of the carbohydrates of the foliage leaf of the snowdrop. He carried out two sets of experiments. Two equal portions of fresh leaves were taken. One portion was dried in the ordinary way, and the sugars from the dried leaves were determined. The other portion was immersed at once in liquid air, then withdrawn, and ground up while frozen and brittle. The powder was at once thrown into hot water to kill the enzymes, a little ammonia added to neutralize any acidity, and the sugars were determined in the aqueous extract. This procedure was designed to eliminate autolysis. The treatment with liquid air was merely to facilitate powdering of the leaves. It was the heat treatment, of course, which destroyed the enzymes. He found that the proportion of sugars in both cases is almost the same, as can be seen from Table 2.

TABLE 2.—*Parkin's data for different methods of sampling leaves for sugar analysis.*[a]

	Sucrose.	Hexoses (reducing sugars).	Total sugar.	Ratio of sucrose to hexose.
Experiment I:				
Fresh leaf	12.84	5.94	18.78	1:0.46
Dried leaf	12.74	5.67	18.41	1:0.44
Experiment II:				
Fresh leaf	10.46	12.87	23.33	1:1.23
Dried leaf	10.42	12.38	22.80	1:1.19

[a] The amounts of the sugars are calculated for 100 grams of dry leaf.

Any autolysis during drying would almost certainly have been reflected in the sugar ratios, since these afford an exceedingly sensitive indication of chemical changes going on in the cell. Parkin's work appears to justify fully the procedure adopted in sampling.

METHODS OF ANALYSIS

Moisture.—Duplicate samples of the powdered leaves, the weight varying from 1.5 to 2.0 grams, were heated in a vacuum oven at from 90° to 95° C. for six hours. The loss of weight was taken as the moisture content.

THE NITROGEN PARTITION

Total nitrogen.—It was decided to use a combination of the Gunning method modified to include the nitrogen of nitrates (26) and the iodometric method of Willard and Cake (53) for the determination of amino nitrogen in organic substances. The nitrate nitrogen of the sample was retained by using salicylic acid and the nitro compound resulting from this treatment was reduced with sodium thiosulphate. The digestion was then carried out in the usual way with concentrated sulphuric acid and potassium sulphate, except that after the addition of potassium sulphate boiling was continued only for an hour at most. The digestion was completed by the addition of potassium persulphate free from ammonium salts, the amount varying from five to ten times the weight of the sample taken. When the destruction of the non-nitrogenous organic matter was complete, the acid solution was made alkaline with sodium hydroxide and the ammonia determined by oxidation to nitrogen with standard sodium hypobromite solution. This was done by adding an excess of the hypobromite to the alkaline solution and titrating the excess back with 0.2 *N* sodium thiosulphate after the addition of potassium iodide and hydrochloric acid.

Ammonia nitrogen.—The determination was made according to Grafe's method.(18) Ten grams of the sample were transferred to a long-necked 500-cubic-centimeter Kjeldahl flask, together with 20 cubic centimeters of concentrated sodium chloride solution, 10 cubic centimeters of 95 per cent ethyl alcohol, 100 cubic centimeters of distilled water, 10 cubic centimeters of saturated sodium carbonate solution (or enough to render the mixture alkaline), and 0.3 cubic centimeter of caprylic alcohol. The mixture was subjected to distillation in vacuo at a temperature ranging from 35 to 37° C. for three hours. The distillate was caught in a known volume of 0.1 *N* sulphuric acid, and the excess acid was titrated back with 0.1 *N* sodium hydroxide, using methyl orange test solution as an indicator. Caprylic alcohol was used to prevent excessive foaming, since it was found that the amount of ethyl alcohol indicated by Grafe was not sufficient for the purpose. A blank determination was carried out and the result subtracted from that given by the sample.

Protein nitrogen.—The protein nitrogen was determined according to Stutzer's method as adopted by the Association of Official Agricultural Chemists for albuminoid nitrogen.(26)

Free amino acid nitrogen.—Two or three grams of the powder were weighed, placed in a 300-cubic-centimeter Erlenmeyer flask, 100 cubic centimeters of distilled water added, and the flask shaken in the shaking machine for half an hour. The content of the flask was transferred to a Buchner funnel and filtered. Of the aqueous extract, two aliquot portions of 10 cubic centimeters were pipetted and used for the determination according to Van Slyke's method.(56)

The rest of the nitrogen, namely, the nitrate, acid amide, humin, basic, nonbasic, and peptide, was determined in the aqueous extract which was prepared from the leaves in the following way:

A 15-gram sample of the powdered leaves was placed in a liter beaker and boiled for thirty minutes with 500 cubic centimeters of distilled water. When cold, the clear supernatant liquid was carefully decanted from the sediment. The treatment was repeated twice, with 250 cubic centimeters of water each time. The boiling was confined to fifteen minutes. The three aqueous extracts were combined and rendered acid with a few drops of acetic acid and then boiled for a few minutes to coagulate the soluble proteins. While hot, the liquid was filtered under pressure through an ordinary filter paper supported underneath by linen. A hardened filter paper could not be used because of the mucilaginous nature of the aqueous extract. When the extract was cold, it was made up to a volume of 1,000 cubic centimeters. No preservative was used in the extract, as the experiment was so arranged that all the determinations were started the same day. The object of setting aside the powdered leaves after they were boiled with water was to allow the fine particles of the powder to settle out so that the clear mucilaginous aqueous extract could be removed by decantation. The method generally followed of filtering the aqueous extract of the leaves immediately after boiling was also tried, but was given up because the extract was so viscous that filtration was very slow.

Water-soluble nitrogen.—Two 50-cubic-centimeter portions of the aqueous extract were transferred to Kjeldahl digestion flasks and evaporated almost to dryness. The total nitrogen was determined in exactly the same way as in the leaf powder, except that 15 cubic centimeters of sulphuric acid, 1 gram of salicylic acid, and 2.5 grams of sodium thiosulphate were used.

Nitrate nitrogen.—The determination was carried out according to Scales's method as modified by Harrison.(20) The principle is the reduction of the nitrate nitrogen to ammonia in alkaline solution by means of some reducing agent and, after reduction, distillation into a known amount of acid, the excess of which is found by titration. Harrison(20) has pointed out the advantage of Scales's method over that of Devarda. Since the method was to be used for the nitrate nitrogen in plant extracts, it was necessary to determine first whether other forms of nitrogen in the extract might also be included. A series of experiments was conducted, using an extract of the sugar beet which was available at that time. Nitrogen in the form of acid amide, amino acid, nitrate, nitrite, and ammonia was added to known volumes of the extract and the amount of nitrogen recovered from each of them was determined. The results of the experiments are shown in Table 3.

TABLE 3.—*Results of nitrate nitrogen determination.*

	N/14 H_2SO_4 consumed.	Nitrogen recovered.	Nitrogen present.	Nitrogen recovered.
	cc.	*mg.*	*mg.*	*Per cent.*
50 cc. of extract	48.90			
50 cc. extract + 0.625 gm. sugar	48.87			
50 cc. extract + 0.25 gm. asparagine + 0.1992 gm. acetanilide	50.90	2.00	73.60	2.71
50 cc. extract + 0.25 gm. asparagine + 0.625 gm. sugar	50.30	1.40	53.00	2.64
50 cc. of extract + 0.25 gm. asparagine	50.70	1.80	53.00	3.39
50 cc. extract + 0.625 gm. sugar + 0.40 gm. alanine	48 70	0.00	62.90	0.00
50 cc. extract + 0.075 gm. KNO_3	59.10	10.20	10.38	98.26
50 cc. extract + 0.0375 gm. KNO_3	54.20	5.30	5.19	102.11
200 cc. distilled water + 0.2038 gm. KNO_3	28.30	28.30	28.20	100.35
200 cc. distilled water + 0.3247 gm. $NaNO_2$	64.30	64.30	65.91	97.55
200 cc. distilled water + 0.1179 gm. NH_4NO_3	39.30	39.30	40.12	97.95
50 cc. extract + 0.05895 gm. NH_4NO_3	68.62	19.72	20.06	98.60

The results indicate that only a small percentage of the nitrogen from acid amides, as in acetanilide, is determined as nitrate by this method. The amino acid nitrogen, as in alanine, remains unaffected. The same holds true, of course, for the two types of nitrogen in asparagine. As was expected, the method accounts for all the nitrogen from nitrites and ammonia—a fact which must be taken into account in using the method. In *Oenothera* leaves, no nitrite was found, so the nitrate nitrogen as determined by this method includes only the ammonia nitrogen. Since the latter is also known, the nitrate nitrogen can be found by difference. The method as adopted was therefore as follows: Two 200-cubic-centimeter portions of the aqueous extract were transferred to 500-cubic-centimeter Kjeldahl digestion flasks which contained 80 grams of zinc-copper couple. Then 6.5 grams of sodium chloride magnesium oxide mixture (5 grams of sodium chloride to 1.5 grams of magnesium oxide) were added to the contents of the flasks and the distillation carried out. The distillate was collected in a known amount of 0.1 *N* sulphuric acid, until 150 cubic centimeters of the distillate were obtained. The excess of acid was determined by titration. A blank experiment, using 200 cubic centimeters of distilled water, was also carried out.

The acid amide, humin, and basic and nonbasic nitrogen of the aqueous extracts were determined according to the method of Hausmann as adopted by Jodidi.(22)

Peptide nitrogen.—A 50-cubic-centimeter sample of the aqueous extract was treated with 10 cubic centimeters of concentrated hydrochloric acid and kept boiling under a reflux condenser for three hours. The acidified extract was evaporated to dryness on the water bath to drive off the acid, and the residue was treated with a small amount of water and filtered. The filtrate was evaporated to about 10 cubic centimeters on the water bath and the nitrogen of the amino acids determined according to Van Slyke's method.(56) The nitrogen found comes from the free amino acids present in the leaves and from the amino acids formed by the breaking down of the peptide linkings by hydrolysis. To obtain the peptide nitrogen, the amino acid nitrogen found before hydrolysis was subtracted from that found after hydrolysis.

The nitrogen partition in the leaves after acid hydrolysis, was carried out according to Jodidi and Moulton's procedure(23) as applied to spinach.

THE CARBOHYDRATES

Sugar.—In the determination of the sugar content of the leaves, effort was first directed to finding an appropriate process of extraction. The cold-water method was first tried but was abandoned because, owing to the slimy nature of the aqueous extract, the leaves could not be extracted repeatedly with cold water; in the second extraction, the extract would hardly pass through the filter. The same difficulty was met when hot water was tried. The use of a dilute solution of alcohol was therefore resorted to. This was found to be a satisfactory solvent. Accordingly, a series of experiments was carried out to determine the strength of alcohol to be used and the length of time required for extraction. Three different strengths of alcohol were tried, and the samples were extracted three successive times. The period of shaking for each extraction was two hours for the first and second series and one hour forty-five minutes for the third and fourth. In the fourth series, in which 10 per cent alcohol was used, it was found that the concentration was not high enough to prevent the extract from becoming slimy. In all cases the alcoholic extract was made up to a definite volume, and the reducing sugar in an aliquot portion of the clarified solution was determined before and after inversion. The reducing sugar was determined by means of Fehling's solution, the precipitation being carried out according to the directions of Munson and Walker,(26) and the copper in the precipitate estimated according to the iodometric method of Low.(26) The results obtained are given in Table 4.

TABLE 4.—*Results of sugar extraction under various conditions.*

Sample No.	Time of shaking.		Alcohol.	Reducing sugar before inversion.	Reducing sugar after inversion.	Reducing sugar freed by hydrolysis.
	Hrs.	*min.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0842—1	6		25	7.42	10.36	2.94
0842—2	6		25	7.46	10.38	2.92
0842—3	6		15	7.41	10.30	2.89
0842—4	6		15	7.44	10.32	2.88
0842—5	1	45	15	7.48	10.38	2.90
0842—6	1	45	15	7.44	10.37	2.93
0842—7	1	45	15	7.34	10.36	3.02
0842—mean				7.43	10.35	2.92

Since the reducing sugar obtained in all series was almost the same, there was no advantage in using a 25 per cent alcohol, nor in allowing the extraction to proceed for a long period of time. To insure perfect extraction of the sugar, it is of course preferable to use a low concentration of alcohol. Since a 10 per cent strength removed some mucilage and was therefore unsatisfactory, the 15 per cent alcohol was chosen for further work.

Since in the previous experiments no precautions were taken to destroy or to inhibit the action of the enzymes present in the leaves, the results were compared with those obtained by using a very strong solution of alcohol as a solvent. A known weight of the sample was placed in a Soxhlet extractor and extracted first with anhydrous ether to remove the chlorophyll and other, fatty substances. The powder was dried and then extracted with 95 per cent alcohol for forty-eight hours. The alcohol of the extract was recovered by distillation under reduced pressure, and the residue was dissolved in water and made up to a definite volume. The reducing sugar in the clarified solution of an aliquot portion of the extract was determined in the same way as in the previous experiments. The residual leaves were dried and extracted with water, to remove the sugar which was not dissolved by the alcohol, and the reducing sugar in the aqueous extract was determined. The results obtained are shown in Table 5.

TABLE 5.—*Comparison of analytical results for sugar with and without taking precautions for the inactivation of enzymes.*

	Sample No.	Reducing sugar before inversion.	Reducing sugar after inversion.	Reducing sugar freed by hydrolysis.
		Per cent.	*Per cent.*	*Per cent.*
Ninety-five per cent alcoholic extract	0842-A	5.66	7.84	2.18
Aqueous extract	0842-A	1.91	2.66	0.75
Total sugar; enzymes inactivated	0842-A	7.57	10.50	2.93
Ninety-five per cent alcoholic extract	0842-B	6.48	8.97	2.49
Aqueous extract	0842-B	1.08	1.44	0.36
Total sugar; enzymes inactivated	0842-B	7.56	10.41	2.85
Mean results of total sugar; enzymes inactivated	0842	7.57	10.46	2.89
Mean results from Table 4; enzymes not inactivated	0842	7.43	10.36	2.92

The sugars found by using strong hot alcohol, to prevent the action of the enzymes, were practically in the same proportions as when weak alcoholic solutions were used. Only a very small portion of the sugars in *Oenothera* leaves is present as nonreducing sugar; hence the enzymatic effect was not appreciable. Furthermore, the presence of even a low concentration of alcohol might possibly retard the enzymatic action.

Since the ordinary method of extraction with a weak solution of alcohol is rapid and yields the same results as more complicated procedures, the method adopted for extraction of the sugars was as follows: A 5-gram sample was transferred to an Erlenmeyer flask, 250 cubic centimeters of 15 per cent alcohol added, and the flask shaken in a shaking machine for one hour. The extract was filtered by suction. The powder with the filter paper was returned to the original flask, 150 cubic centimeters of the alcoholic solution were added, and the flask was shaken for thirty minutes. The extract was filtered and the process repeated, using 100 cubic centimeters of the alcoholic solution and shaking for fifteen minutes. The combined alcoholic extracts were made up to a volume of 500 cubic centimeters. An aliquot portion of the extract was at once withdrawn, clarified with lead subacetate solution, and the excess lead removed with sodium carbonate. The reducing sugar in the clarified solution before and after inversion was then determined according to the method already described.

Pentosan.—The pentosan was determined in a sample of the dried leaves according to the method adopted by the Association of Official Agricultural Chemists for pentosans in foods and feeding stuffs.(26)

Starch.—In *Oenothera* leaves tannins occur in such considerable amounts that they must be removed before the starch can be determined by the diastase method with subsequent acid hydrolysis. Accordingly, a given amount of the powdered leaves was extracted in a Soxhlet extractor with 95 per cent alcohol for forty-eight hours. The powder was allowed to dry and then treated with cold water to remove any residual tannin that is insoluble in 95 per cent alcohol. The powder after undergoing this treatment was transferred to a beaker, 50 cubic centimeters of water added, and the starch determined according to the directions given in the Journal of the Association of Official Agricultural Chemists,(26) except that the dextrose resulting from the hydrolysis of starch was estimated according to the method adopted for the free reducing sugar.

Tannin.—The tannin was determined according to the Proctor modification of the Löwenthal method as applied to tea by the Association of Official Agricultural Chemists.(26) In *Oenothera* leaves, which give a mucilaginous aqueous extract, it was found best to set aside the leaf infusion overnight, after which the supernatant liquid could be decanted.

Crude fiber.—A 2-gram sample of the leaves was extracted with ordinary ether in a Soxhlet extractor until the percolate was colorless. The leaves were dried and the crude fiber determined according to the directions given in the Journal of the Association of Official Agricultural Chemists for crude fiber in foods and feeding stuffs.(26)

The water-soluble acids.—A 5-gram sample of the leaves was transferred to an Erlenmeyer flask, 200 cubic centimeters of distilled water added, and the whole shaken for thirty minutes. The extract was filtered by suction. A 20-cubic-centimeter aliquot portion of the filtrate was diluted with 100 cubic centimeters of distilled water and titrated with 0.1 N sodium hydroxide using phenolphthalein as an indicator. The total acids found were expressed in terms of the number of milligrams of sodium hydroxide required to neutralize the acids from one gram of moisture-free sample.

Total ash.—A sample, weighing 2 to 3 grams, was incinerated in a platinum crucible at a low heat until it was reduced to a gray ash. It was cooled, treated with hot water to dissolve the soluble salts, and filtered. The filter paper with the carbonaceous residue was transferred to the original crucible, dried, and heated to full redness until the ash was white. The filtrate was evaporated to a small volume on the water bath and the concentrated solution was added a little at a time to the crucible containing the insoluble ash and the whole evaporated to dryness on the water bath. A few cubic centimeters of strong ammonium carbonate were added in order to change the alkaline earth oxides into their carbonates. The crucible was then heated in a free flame to a very dull red heat until a constant weight was obtained. The ash is reported as containing carbonates.

THE INORGANIC CONSTITUENTS OF THE ASH

A 30-gram sample of the leaves was incinerated at a low heat in a porcelain dish until a gray ash was obtained. The ash was then treated in the same way as in the determination of the total ash. In this case, of course, a large platinum dish was used. The ash obtained was pulverized and kept in a well-stoppered bottle. An aliquot portion of the ash, weighing from 2.5 to 3 grams, was treated with 200 cubic centimeters of 10 per cent hydrochloric acid and the solution evaporated to complete dryness on the water bath in order to dehydrate the silica. The residue was taken up with 100 cubic centimeters of 10 per cent hydrochloric acid and 200 cubic centimeters of warm water. It was filtered, washed thoroughly with water, and the filtrate after cooling was made up to 500 cubic centimeters. In the subsequent determinations, this filtrate was referred to as the original solution.

Silica.—The residue obtained in the preparation of the solution of the ash was treated according to directions given in the official methods of the Association of Official Agricultural Chemists for silica in plants.(26) The silica was estimated by the loss of weight of the residue when treated with hydrofluoric acid.

Calcium.—A 100-cubic-centimeter sample of the original solution was taken and the calcium precipitated as oxalate according to directions given by Mitchell.(32) The calcium oxalate was dissolved in hot 10 per cent sulphuric acid and at once titrated with 0.1 *N* potassium permanganate.

Magnesium.—To the filtrate and washings from the calcium determination, 25 cubic centimeters of concentrated nitric acid were added and the acid liquid was evaporated to complete dryness on the water bath. The residue was taken up with dilute hydrochloric acid and the magnesium was precipitated as magnesium ammonium phosphate according to the method given by Mitchell.(32) The precipitate was ignited, and weighed as magnesium pyrophosphate.

Phosphoric acid.—The phosphoric acid was determined in 50 cubic centimeters of the original solution by one of the methods given in the Journal of the Association of Official Agricultural Chemists,(26) in which the phosphoric acid was precipitated as ammonium phosphomolybdate, and the precipitate was dissolved in a known excess of 0.1 *N* sodium hydroxide, the excess alkali being determined by titration.

Sulphuric acid.—The determination was carried out according to directions given in the official methods of the Association of Official Agricultural Chemists, 100 cubic centimeters of the original solution being used.

Potassium and sodium.—The filtrate and washings from the sulphuric acid determination were treated according to the directions given in the official methods of the Association of Official Agricultural Chemists(26) for potassium and sodium in plant products. When the potassium and sodium chlorides were obtained, the separation of potassium was accomplished by the perchlorate method, following in detail the directions given by Willard.(52)

PRESENTATION OF RESULTS

In all the tables the results are the mean of two determinations which agreed with each other within the limit of experimental error. Unless otherwise stated, the results are expressed as percentages of the moisture-free samples. In the list of the strains studied and in the tabulation of results, the pistillate parent is named first and then the pollen parent in all strains which resulted from crosses.

THE NITROGEN DISTRIBUTION

The chief nitrogenous compounds from the point of view of their importance in the life processes of the plant are the proteins, amino acids, peptides, acid amides, nitrates, and some of the nitrogen bases. The nitrogen source for the parasitic fungi is of course the body of the host. The fungi may conceivably obtain their nitrogen either by direct absorption of the soluble simpler nitrogenous compounds or by the digestion of colloidal compounds, which are, as far as known, proteins.

The major portion of the nitrogenous constituents of the plant is protein which, at least as far as storage protein is concerned, is continually being decomposed into amino-acid units and again resynthesized. In a diseased plant, the fungus must disturb the normal nitrogen distribution, even if it uses only amino acids produced in a normal manner by the host, whether by primary synthesis or by autodigestion of protein. Disturbance might be even greater if the fungus excreted proteases which digested the plant proteins independently of the normal metabolism of the host. It is, therefore, a logical expectation that the nitrogen distribution in healthy plants will not be the same as it is in diseased plants.

Among the first investigators to find significant differences in the nitrogen distribution between healthy and diseased plants was Jodidi.(22) He studied the nitrogenous constituents of healthy and mosaic cabbage, and with Moulton and Markley(24) extended his investigation to the mosaic disease of spinach. In both plants the diseased individuals were found to have a lower percentage of total nitrogen, acid amide, monoamino and diamino-nitrogen than the normal ones. Moreover, nitrous acid was present only in the diseased plants. These characteristic features of the diseased cabbage and spinach were ascribed to denitrification in the affected tissues, by which nitrates were reduced in part to ammonia and in part to nitrites. The latter reacting with the amino groups of the various organic compounds brought about the elimination of elementary nitrogen. There is room for doubt as to the correctness of Jodidi's explanation. However, his results show conclusively that in mosaic plants the nitrogen distribution is different from that in normal ones. Since no causal organism has been demonstrated for the mosaic diseases, there was no reason to look for findings parallel to Jodidi's in the present investigation of mildewed *Oenothera*. The results are, in fact, very diverse. As far as I know, no previous investigation has dealt in a thoroughgoing way with a known fungus infection from the standpoint of nitrogen distribution.

Total nitrogen.—In *Oenothera*, there exists a remarkable difference in the proportion of the various groups of nitrogen compounds in the resistant and susceptible strains. First of all, let us consider the results obtained for total nitrogen, which are shown in Table 6.

TABLE 6.—*Percentage of total nitrogen in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Nitrogen in 1920.	Nitrogen in 1921.	Nitrogen in 1922.
			Per cent.	*Per cent.*	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	2.55	--------	--------
1a			-------	2.59	--------
1b			-------	--------	2.54
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.39	--------	--------
2a			-------	3.61	--------
2b			-------	--------	3.03
3	*Oe. pratincola* hyb. *immunis*	Resistant	2.59	--------	--------
3a			-------	2.79	--------
3b			-------	--------	2.29
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.55	--------	--------
4a			-------	3.87	--------
4b			-------	--------	3.08
5	*Oe. mississippiensis* ×	Resistant	3.03	--------	--------
5a	*Oe. pratincola* hyb. *immunis*		-------	3.25	--------
6	*Oe. pratincola* hyb. *immunis* ×	Susceptible	3.38	--------	--------
6a	*Oe. mississippiensis*		-------	3.57	--------
7	*Oe. mississipiensis* × *Oe. pratincola* hyb. *immunis*	Resistant	3.00	--------	--------
8	*Oe. cinerescens* ×	do	-------	3.22	--------
8a	*Oe. pratincola* hyb. *immunis*		-------	--------	2.45
9	*Oe. pratincola* hyb. *immunis* ×	Susceptible	-------	3.65	--------
9a	*Oe. cinerescens*		-------	--------	2.81
10	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis*	Resistant	3.13	--------	--------
11	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago"*	Susceptible	3.62	--------	--------
12	*Oe. cinerescens* × *Oe. mississippiensis*	Resistant	2.64	--------	--------
13	*Oe. mississippiensis* × *Oe. cinerescens*	Susceptible	2.93	--------	--------
13a			-------	2.93	--------
13b			-------	--------	2.69
14	*Oe. cinerescens* ×	do	-------	2.86	--------
14a	*Oe. mississippiensis* (metaclinic hybrid)		-------	--------	2.64
15	*Oe. pratincola* × *Oe. reynoldsii* (*Oe. pratincola* hyb. *amycosa*).	Resistant	2.22	--------	--------
16	*Oe. reynoldsii* × *Oe. pratincola*	Susceptible	2.71	--------	--------
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*	do	3.13	--------	--------
17a			-------	2.93	--------
17b			-------	--------	2.68
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago"*	do	3.74	--------	--------
18a			-------	3.16	--------
18b			-------	--------	2.81
19	*Oe. mississippiensis* × *Oe. "biennis Chicago"*	do	2.88	--------	--------
20	*Oe. "biennis Chicago"* × *Oe. mississippiensis*	do	3.25	--------	--------
21	*Oe. "biennis Chicago"* × *Oe. mississippiensis*	do	3.08	--------	--------

TABLE 6.—*Percentage of total nitrogen in the leaves of different strains of Oenothera*—Continued.

Key No.	Name of strain.	Characteristic of strain.	Nitrogen in 1920.	Nitrogen in 1921.	Nitrogen in 1922.
			Per cent.	*Per cent.*	*Per cent.*
24	*Oe. pratincola* mut. *nitidissima*	Resistant	--------	2.79	--------
24a	do	do	--------	2.92	--------
25	do	Susceptible	--------	3.23	--------
25a	do	do	--------	3.16	--------
26	*Oe. numismatica*	Resistant	--------	2.40	--------
27	*Oe. pratincola* mut. *simulans*	do	--------	2.34	--------
29a	*Oe. pratincola* hyb. *immunis*	do	--------	--------	2.54
33	*Oe. reynoldsii*	do	--------	2.28	--------
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	--------	--------	2.95
35	*Oe. "biennis Chicago"*	do	--------	--------	2.91

(*a*) For all pairs of reciprocal hybrids, the susceptible members of the pairs contain a higher percentage of total nitrogen than do the resistant ones. This difference persisted in the strains grown for three consecutive years.

(*b*) The same statement holds true for elementary species. The resistant species are found to have less total nitrogen than the susceptible species.

(*c*) In *Oenothera pratincola* mut. *nitidissima* (key Nos. 24–25), which occurs in susceptible and resistant forms, the susceptible form has a higher total nitrogen than the resistant one. This mutation, as has been stated elsewhere in this paper, has been recovered in many progenies of crosses into which it entered, unchanged except for modification of its susceptibility.

(*d*) Pairs of strains which have the same genetic composition but belong to different pedigrees, contain almost the same percentage of total nitrogen. This fact is shown in the crosses *Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis* (key Nos. 5 and 7) and *Oe. mississippiensis* × *Oe. "biennis Chicago"* (key nos. 19 and 21).

(*e*) A striking situation is provided by the reciprocal hybrids from crosses between *Oe. cinerescens* (immune) and *Oe. mississippiensis* (susceptible). The hybrid (key No. 12), in which *Oe. cinerescens* is the pistillate parent, is resistant and therefore has a lower total nitrogen than the reciprocal hybrid *Oe. mississippiensis* × *Oe. cinerescens* which is susceptible (key No. 13). But the metaclinic hybrid *Oe. cinerescens* × *Oe. mississippiensis* (key No. 14), being of the type *Oe. mississippiensis*, is susceptible. We should expect it to show a higher total nitrogen than the resistant matroclinic plants (key No. 12) and this is exactly the case, for the percentage of total nitrogen found is almost the same as in its reciprocal hybrid, where *Oe. mississippiensis* is the pistillate parent (key No. 13). The two were grown for two successive years, and the difference in their total nitrogen is very slight. The data for the F_2 generation of the resistant hybrid are lacking, as the self-pollinated matroclinic plant of the F_1 gave no seeds. Genetical data regarding this metaclinic hybrid are given by Klaphaak and Bartlett.(27)

(*f*) In pairs of reciprocal hybrids in which both members are susceptible, the total nitrogen is comparatively high and the difference between reciprocals is slight. The only exception is found in the results for 1920 of the crosses between *Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*, where the variation in total nitrogen is rather high. But the same reciprocal hybrids, when grown in 1921 and 1922, show much less difference. Since the collection for 1920 was made when the plants were approaching senescence, presumably the cause of the variation is traceable to this fact. Hybrids of this type are shown in Table 6 under key Nos. 17 and 18 and Nos. 19 and 20.

(*g*) In crosses between resistant and susceptible parents, the resistant hybrid and the resistant parent exhibit a low percentage of total nitrogen. The reverse is true for the susceptible members, which both have high total nitrogen. Thus, resistant *Oe. pratincola* (key No. 1), a segregate from a species hybrid, and its reciprocal hybrid, mildewed *Oe. pratincola* (key No. 2), come from *Oe. pratincola* hyb. *immunis* (key No. 29a) and *Oe. pratincola* hyb. *rubricalyx* (key No. 34). Resistant *Oe. pratincola,* according to Klaphaak and Bartlett,(27) has the zygotic composition $\alpha\hat{\iota}\beta\mathrm{I}$ and hence it is immune. (The formation takes account only of the immunity factor.) Its resistant parent, *Oe. pratincola* hyb. *immunis,* has also the zygotic composition $\alpha\hat{\iota}\beta\mathrm{I}$. Both of them have 2.54 per cent total nitrogen. The mildewed *Oe. pratincola* has also the same zygotic composition as its susceptible parent, *Oe. pratincola* hyb. *rubricalyx,* which is $\alpha\hat{\iota}\beta\iota$, and their total nitrogen varies only very slightly. The hybrid has 3.03 per cent and the parent has 2.95 per cent.

(*h*) In crosses between two susceptible parents, the resultant hybrids, which are both susceptible, agree rather closely with their parents in having a proportionately high total nitrogen. This fact is illustrated by crosses between *Oe. pratincola* hyb. *rubricalyx* and *Oe. "biennis Chicago"* (key Nos. 17b, 18b, 34, and 35).

TABLE 7.—*Nitrogen partition in the leaves of the different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Total nitrogen.	Water-soluble nitrogen.	Protein nitrogen.	Free amino-acid nitrogen.	Nitrate nitrogen.	Ammonia nitrogen.	Water-soluble nitrogen.				
									Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.	Peptide nitrogen.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	2.54	0.427	2.09	0.235	0.069	0.055	0.162	0.151	0.092	0.022	0.106
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.03	0.607	2.46	0.311	0.087	0.076	0.127	0.188	0.121	0.171	0.020
3b	*Oe. pratincola* hyb. *immunis*	Resistant	2.29	0.709	1.55	0.421	0.132	0.105	0.254	0.194	0.109	0.152	0.00
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.08	1.06	2.03	0.588	0.188	0.137	0.327	0.219	0.107	0.407	0.067
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.*	Resistant	2.45	0.575	1.97	0.351	0.138	0.031	0.168	0.185	0.095	0.127	0.056
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens.*	Susceptible	2.81	0.848	1.99	0.446	0.154	0.037	0.213	0.188	0.118	0.329	0.00
17b	*Oe.* "*biennis Chicago*" × *Oe. pratincola* hyb. *rubricalyx.*	do	2.68	0.667	2.08	0.537	0.157	0.093	0.218	0.177	0.091	0.181	0.014
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe.* "*biennis Chicago.*"	do	2.81	0.757	2.11	0.433	0.147	0.093	0.244	0.169	0.112	0.232	0.025
29a	*Oe. pratincola* hyb. *immunis*	Resistant	2.54	0.740	1.82	0.482	0.115	0.098	0.215	0.152	0.071	0.301	0.00
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	2.95	0.933	2.09	0.739	0.166	0.117	0.277	0.193	0.098	0.365	0.00
35	*Oe.* "*biennis Chicago*"	do	2.91	1.06	2.00	0.626	0.190	0.116	0.318	0.123	0.127	0.492	0.133

In view of the concordant results obtained from all the possible crosses and elementary species, it can be stated that susceptible plants are characterized by having a higher total nitrogen than closely related resistant ones.

Water-soluble nitrogen.—To determine which forms of nitrogen are responsible for the difference in total nitrogen, the nitrogen distribution was determined for four pairs of reciprocal hybrids and three elementary species. It is to be noted that the figures for acid amide and ammonia, humin, and basic and nonbasic nitrogen, given in Tables 7 and 8, were obtained after acid hydrolysis of the water-soluble extract, hence they account for the nitrogen from the water-soluble portion only. Results in Table 7 indicate that: (*a*) in the three pairs of reciprocal hybrids which consist of resistant and susceptible members (key Nos. 1b–9a), the water-soluble nitrogen as a whole and its amino acid and nonbasic nitrogen compounds are higher in the susceptible hybrids than in their resistant reciprocals. The nitrate nitrogen in the susceptible hybrids is somewhat higher than in the resistant ones but the difference is not sufficient to be considered significant. As for the protein nitrogen, in the first two pairs (key Nos. 1b–4b) the susceptible hybrids contain higher protein nitrogen than the resistant ones, but in the third pair (key Nos. 8a–9a) their protein nitrogen is about the same. Other forms of nitrogen do not show concordant results. (*b*) In the fourth pair of reciprocal hybrids, in which both members are susceptible (key Nos. 17b–18b), the water-soluble nitrogen is high and the percentage of the different forms of nitrogen in the water-soluble fraction of both strains does not vary considerably. (*c*) The resistant parent shows the same characteristic features, when compared with the susceptible parent, as its resistant offspring; namely, low water-soluble nitrogen, amino acid, and nonbasic nitrogen. Conversely, the susceptible parent and its susceptible progeny resemble each other in having high water-soluble nitrogen, amino acid, and nonbasic nitrogen.

When the results of the nitrogen distribution, shown in Table 7, are expressed as percentage of the total nitrogen of the leaves, it can be seen that the water-soluble nitrogen is also higher in the susceptible strains than in the resistant ones. The two main components of the water-soluble nitrogen which account for this difference are the free amino acid and the nonbasic nitrogen. For the protein nitrogen, the reverse is found to be the case. (See Table 8.)

TABLE 8.—*Nitrogen partition in the leaves of the different strains of Oenothera.*

[Data expressed as percentage of the total nitrogen of the leaves.]

Key No.	Name of strain.	Characteristic of strain.	Water-soluble nitrogen.	Protein nitrogen.	Free amino-acid nitrogen.	Nitrate nitrogen.	Ammonia nitrogen.	Water-soluble nitrogen.				
								Acid amide and ammonia nitrogen	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.	Peptide nitrogen.
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	16.81	82.28	9.25	2.72	2.17	6.38	5.94	3.62	0.866	4.17
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	20.03	81.19	10.26	2.87	2.51	4.19	6.21	3.99	5.64	0.660
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*.	Resistant	23.47	80.41	14.33	5.63	1.27	6.86	7.55	3.88	5.18	2.29
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*.	Susceptible	30.18	70.82	15.87	5.48	1.32	7.58	6.69	4.20	11.71	0.00
3b	*Oe pratincola* hyb. *immunis*	Resistant	30.96	67.69	18.39	5.76	4.59	11.09	8.47	4.76	6.64	0.00
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	34.42	65.94	19.09	6.10	4.45	10.79	7.11	3.47	13.21	2.18
17b	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	do	24.89	77.61	10.04	5.86	3.47	8.13	6.60	3.40	6.75	0.522
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe.* "*biennis* Chicago".	do	26.94	76.09	15.41	5.23	3.31	8.68	6.01	3.99	8.26	0.889
29a	*Oe. pratincola* hyb. *immunis*	Resistant	29.13	71.65	18.98	4.53	3.86	8.50	5.98	2.80	11.85	0.00
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	31.63	70.85	25.05	5.63	3.97	9.39	6.54	3.32	12.37	0.00
35	*Oe. "biennis Chicago"*	do	36.43	68.73	21.51	6.53	3.99	10.93	4.23	4.36	16.91	4.57

Protein nitrogen.—In order to determine the nitrogen partition in the protein, the leaf powder was treated with strong hydrochloric acid and boiled under a reflux condenser for several hours. After hydrolysis was complete, the nitrogen distribution was determined, according to the methods of Hausmann as adopted by Jodidi and Moulton (23) in their work with spinach. The results of the experiments are shown in Tables 9 and 10.

TABLE 9.—*Nitrogen partition in the leaves of different strains of Oenothera after acid hydrolysis.*

Key No.	Name of strain.	Characteristic of strain.	Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	0.254	0.237	0.398	1.651
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.370	0.230	0.499	1.931
3b	*Oe. pratincola* hyb. *immunis*	Resistant	0.384	0.218	0.384	1.354
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.556	0.249	0.476	1.799
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.*	Resistant	0.307	0.226	0.379	1.538
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens.*	Susceptible	0.372	0.213	0.397	1.828
13b	*Oe. mississippiensis* × *Oe. cinerescens.*	do	0.467	0.251	0.379	1.593
14b	*Oe. cinerescens* × *Oe. mississippiensis* (metaclinic hybrid).	do	0.466	0.196	0.360	1.618
17b	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx.*	do	0.404	0.257	0.404	1.615
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago".*	do	0.371	0.258	0.417	1.764
29a	*Oe. pratincola* hyb. *immunis*	Resistant	0.342	0.180	0.436	1.582
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	0.465	0.255	0.489	1.741
35	*Oe. "biennis Chicago"*	do	0.434	0.160	0.525	1.791

Table 9 shows that, in the first two pairs of reciprocal hybrids (key Nos. 1b–4b), the acid amide and ammonia nitrogen and the basic nitrogen are higher in the susceptible hybrids than in their resistant reciprocals. In the third pair (key Nos. 8a–9a), however, this difference is not shown to a great extent. With respect to the nonbasic nitrogen, the susceptible hybrids were found to have a higher percentage. The case of the fourth pair, where *Oe. mississippiensis* and *Oe. cinerescens* are the parents (key Nos. 13b–14b), is interesting. One of the members of the pair is a metaclinic hybrid and, as far as their reaction to mildew is concerned, both are represented as having the same zygotic composition. Their total nitrogen has already been found to be practically the same (Table 6) and here the nitrogen distribution differs to but a slight degree. The fifth pair of reciprocal hybrids (key Nos. 17b and 18b), both members being susceptible, have high acid amide and ammonia nitrogen, and basic and nonbasic nitrogen. Furthermore, the difference between them is slight. Of the parent species (key Nos. 29a-35), the susceptible ones have higher acid amide and ammonia, basic, and nonbasic nitrogen than the resistant one.

TABLE 10.—*Nitrogen partition in the leaves of different strains of Oenothera after acid hydrolysis.*

[Data expressed as percentage of the total nitrogen of the leaves.]

Key No.	Name of strain.	Characteristic of strain.	Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	10.00	9.33	15.67	65.00
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	12.21	7.59	16.47	63.73
3b	*Oe. pratincola* hyb. *immunis*	Resistant	16.77	9.52	14.59	59.12
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	18.05	8.08	15.45	58.40
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*.	Resistant	12.53	9.22	15.47	62.78
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*.	Susceptible	13.24	7.58	14.13	65.05
13b	*Oe. mississippiensis* × *Oe. cinerescens*.	do.	17.36	9.33	14.09	59.22
14b	*Oe. einerescens* × *Oe. mississippiensis* (metaclinic hybrid).	do.	17.65	7.42	13.64	61.29
17b	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	do.	14.38	9.15	14.38	57.47
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do.	13.84	9.63	15.55	65.82
29a	*Oe. pratincola* hyb. *immunis*	Resistant	13.46	7.09	17.17	62.28
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	15.76	8.64	16.58	59.01
35	*Oe. "biennis Chicago"*	do.	14.91	5.50	18.04	61.54

Table 10 shows that the total nitrogen of all the susceptible strains is higher than that of the resistant strains in acid amide and ammonia nitrogen. On the other hand, the total nitrogen of the resistant strains is higher in humin nitrogen than that of the susceptible ones. As for the other nitrogen groups, the results are not concordant.

The nitrogen distribution after acid hydrolysis includes both the nitrogen from the insoluble portion and from the water-soluble portion. Since the nitrogen distribution in the water-soluble portion has also been determined, the different forms of nitrogen corresponding to the water-insoluble or protein portion can be found approximately by subtraction. In the water-insoluble portion, Table 11, it can be noticed that the acid amide and ammonia nitrogen, as well as the nonbasic nitrogen, are higher in the susceptible strains than in the resistant ones. An exception occurs in *Oe. "biennis Chicago,"* one of the parent species, where the acid amide and ammonia nitrogen and the nonbasic nitrogen are somewhat low. However, when these nitrogen groups of the water-insoluble portions are expressed in percentages of the total nitrogen of the leaves, Table 12, the only significant difference that can be noticed is in the nonbasic nitrogen. With respect to this group, the resistant strains are higher than the susceptible. With the exception of *Oe. pratincola* hyb. *immunis*, a parent strain (key No. 29a), the humin nitrogen is also higher in the resistant strains.

TABLE 11.—*Nitrogen partition in the water-insoluble portion of the leaves of different strains of Oenothera, after acid hydrolysis.*

Key No.	Name of strain.	Characteristic of strain.	Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	0.092	0.086	0.306	1.629
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.243	0.042	0.378	1.760
3b	*Oe. pratincola* hyb. *immunis*	Resistant	0.130	0.024	0.225	1.202
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.229	0.030	0.369	1.392
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*.	Resistant	0.139	0.041	0.284	1.411
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*.	Susceptible	0.159	0.025	0.279	1.499
17b	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	do	0.186	0.080	0.318	1.434
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	0.127	0.089	0.305	1.532
29a	*Oe. pratincola* hyb. *immunis*	Resistant	0.126	0.028	0.385	1.281
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	0.188	0.062	0.391	1.376
35	*Oe."biennis Chicago"*	do	0.116	0.037	0.398	1.299

TABLE 12.—*Nitrogen partition in the water-insoluble portion of the leaves of different strains of Oenothera, after acid hydrolysis.*

[Data expressed as percentage of the total nitrogen of the leaves.]

Key No.	Name of strain.	Characteristic of strain.	Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	3.62	3.39	12.02	64.13
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	8.02	1.78	12.48	58.09
3b	*Oe. pratincola* hyb. *immunis*	Resistant	5.68	1.05	9.83	52.48
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	7.26	0.97	11.98	45.19
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*.	Resistant	5.67	1.67	12.59	37.60
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*.	Susceptible	5.66	0.89	9.93	53.34
17b	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	do	6.25	2.55	10.98	50.72
18b	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	5.16	3.62	11.56	57.56
29a	*Oe. pratincola* hyb. *immunis*	Resistant	4.96	1.11	14.37	50.43
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	6.37	2.11	13.26	46.64
35	*Oe. "biennis Chicago"*	do	3.98	1.27	13.68	44.63

For the purpose of obtaining some information relative to the nitrogen distribution in the leaves of resistant and susceptible strains when they are approaching senescence and the mildew is no longer multiplying, the nitrogen distribution of three pairs of reciprocal hybrids collected in 1920 was determined. The results are shown in Tables 13 to 16. Only two concordant results are indicated in Tables 13 and 14. These are for the free amino acid nitrogen and the protein nitrogen. The resistant hybrids of the first two pairs contain more free amino acid than their corresponding reciprocals. On the other hand, the protein nitrogen of the susceptible hybrids is a great deal higher than that of the resistant ones. The difference in the free amino acid, however, loses its significance, since the last pair, in which both reciprocal hybrids are susceptible, is also found to vary in amino acid nitrogen. Therefore, the cause of the consistent difference of the total nitrogen found in the resistant and susceptible strains must be sought in the protein group. From Table 15, which shows the nitrogen distribution after acid hydrolysis, it is seen that the nitrogen from the basic and nonbasic units is higher in the susceptible strains than in the resistant. The humin nitrogen,

TABLE 13.—*Nitrogen partition in the leaves of different strains of Oenothera during the period when the leaves show signs of chlorophyll degradation (cultures of 1920).*

Key No.	Name of strain.	Characteristic of strain.	Total nitrogen.	Water-soluble nitrogen.	Protein nitrogen.	Free amino acid nitrogen.	Ammonia nitrogen.	Nitrate nitrogen.	Water-soluble nitrogen.			
									Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Nonbasic nitrogen.
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant------	2.560	0.627	1.965	0.423	0.089	0.129	0.322	0.081	0.147	0.077
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible----	3.385	0.389	3.045	0.263	0.031	0.080	0.128	0.070	0.089	0.096
3	*Oe. pratincola* hyb. *immunis*---------------	Resistant------	2.585	0.277	2.254	0.185	0.017	0.031	0.058	0.020	0.056	0.143
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible----	3.547	0.406	3.150	0.130	0.044	0.073	0.092	0.057	0.071	0.176
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	-----do--------	3.129	0.300	2.809	0.166	0.020	0.017	0.053	0.029	0.050	0.168
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	-----do--------	3.969	0.741	3.185	0.467	0.036	0.081	0.207	0.032	0.075	0.427

TABLE 14.—*Nitrogen partition in the leaves of different strains of Oenothera during the period when the leaves show signs of chlorophyll degradation (cultures of 1920).*

[Data expressed as percentage of the total nitrogen of the leaves.]

Key No.	Name of strain.	Characteristic of strain.	Water-soluble nitrogen.	Protein nitrogen.	Free amino acid nitrogen.	Nitrate nitrogen.	Ammonia nitrogen.	Water-soluble nitrogen.			
								Acid amide and ammonia nitrogen.	Humin nitrogen.	Basic nitrogen.	Non-basic nitrogen.
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	24.49	76.75	16.52	5.04	3.48	12.58	3.16	5.74	3.01
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	11.49	89.95	7.77	2.36	0.92	3.78	2.24	2.63	2.84
3	*Oe. pratincola* hyb. *immunis*	Resistant	10.72	87.20	7.16	1.20	0.66	2.24	0.77	2.17	5.53
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	11.45	88.81	3.67	2.06	1.24	2.59	1.61	2.00	4.96
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx.*	do	9.59	89.77	5.31	0.54	0.64	1.69	0.93	1.60	5.36
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	18.67	80.25	11.77	2.04	0.91	5.22	0.81	1.89	10.75

TABLE 15.—*Nitrogen partition in the leaves of different strains of Oenothera during the period when the leaves show signs of chlorophyll degradation (cultures of 1920).*

[After acid hydrolysis.]

Key No.	Name of strain.	Characteristic of strain.	Acid amide nitrogen in—		Humin nitrogen in—		Basic nitrogen in—		Nonbasic nitrogen in—	
			Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Resistant *Oe.* ***pratincola*** (a segregate from species hybrid).	Resistant	0.492	19.22	0.215	8.398	0.395	15.43	1.458	56.95
2	Mildewed *Oe.* ***pratincola*** (a segregate from species hybrid.)	Susceptible	0.377	11.14	0.119	3.516	0.527	15.57	2.362	69.78
3	*Oe. pratincola* hyb. ***immunis***	Resistant	0.216	8.356	0.315	12.19	0.492	19.03	1.562	60.42
4	Mildewed *Oe.* ***pratincola*** (a segregate from species hybrid).	Susceptible	0.339	9.557	0.189	5.328	0.722	20.36	2.297	64.76
17	*Oe. "biennis Chicago"* × *Oe.* ***pratincola*** hyb. ***rubricalyx.***	do	0.309	9.875	0.177	5.657	0.697	22.28	1.946	62.19
18	*Oe. pratincola* hyb. ***rubricalyx*** × *Oe. "biennis Chicago."*	do	0.458	11.54	0.241	6.072	0.793	19.98	2.477	62.41

TABLE 16.—*Nitrogen partition in the water-insoluble portion of the leaves of different strains of Oenothera during the period when the leaves show signs of chlorophyll degradation (cultures of 1920).*

Key No.	Name of strain.	Characteristic of strain.	Acid amide nitrogen in—		Humin nitrogen in—		Basic nitrogen in—		Nonbasic nitrogen in—	
			Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.	Moisture-free leaves.	Total nitrogen of leaves.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	0.170	6.67	0.134	5.238	0.248	9.690	1.381	53.94
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.249	7.36	0.043	1.276	0.438	12.940	2.266	66.94
3	*Oe. pratincola* hyb. *immunis*	Resistant	0.158	6.116	0.295	11.42	0.436	16.86	1.419	54.89
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	0.247	6.967	0.132	3.718	0.651	18.36	2.121	59.80
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx.*	do	0.256	8.185	0.148	4.727	0.647	20.68	1.778	56.83
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	0.251	6.32	0.209	5.262	0.718	18.09	2.050	51.65

however, is higher in the resistant hybrids than in their corresponding susceptible reciprocals. These differences are not shown by the last pair, where both reciprocal hybrids are susceptible. Furthermore, as can be seen from Table 16, these differences are traceable to the forms of nitrogen in the water-insoluble portion, which is made up mostly of protein. It seems, therefore, that the water-soluble nitrogenous constituents of the leaves are the ones whose variations show consistent correlations with the occurrence of mildew.

The results of the nitrogen distribution, as a whole, lead to the following conclusions:

1. The main difference between resistant and susceptible strains lies in the water-soluble nitrogen, the susceptible strains having a considerably higher value than the resistant.
2. The forms of combination that are responsible for the difference are the free amino acid and the nonbasic nitrogen, the susceptible plants being characterized by having higher values than the resistant plants.
3. The total nitrogen of the resistant strains has a higher proportion of protein than that of the susceptible ones, the difference being due to the protein nitrogen of nonbasic character.
4. Strains which have the same genetic composition with respect to their reactions to mildew have also practically the same nitrogen distribution.
5. In pairs of reciprocal hybrids both of which are susceptible, the water-soluble nitrogen and the free amino acid are comparatively high and there is not much difference in the distribution.
6. The parent species exhibit the same characteristic differences as the contrasting reciprocal hybrids derived from them.

THE CARBOHYDRATES

The significant differences in the sugar content of the *Oenothera* strains are shown in Table 17. Other carbohydrates do not show consistent correlations with mildew resistance. When the plants are approaching maturity and the mildew on the leaves of the susceptible plants is no longer growing, the amounts of sugar in the resistant and in the susceptible strains do not differ considerably. Furthermore, the slight variation observed is not always in the same direction. In the majority of cases, the sugar content of the resistant strains is higher than that of the susceptible ones. This observation is based upon the analyses of the samples collected in 1920. However, when the same strains were grown in the following years and their leaves collected at the time when the plants were in active growth, at which time the mildew was also most active, the results of the sugar determinations were strikingly correlated with infection.

The figures for 1921 and 1922 in Table 17 show that the total sugar by acid hydrolysis and the free reducing sugar are higher in the resistant strains than in the susceptible ones. Moreover, in the pair in which both reciprocal hybrids are susceptible (key Nos. 17b–18b), the amount of sugar is extremely low, whereas senescent leaves of the same pair had a high sugar content in 1920. It was thought at first that this variation might be ascribed to the fact that in the susceptible strains the mildew is continually using a part of the sugar. It also seemed possible that in the leaves covered with mildew photosynthesis would be retarded. If these factors operated, one would expect to find more sugar in the full-grown leaves before infection than after. With this point in mind, the sugar content was determined in the leaves of different strains of *Oenothera* collected at two different periods of growth. The results in Table 18 are not in accord with the expectation, for it can be seen that in the case of the resistant strains the sugar content for the two periods is comparatively high, while in the susceptible strains the amount of sugar is even less in the leaves collected before infection than in those collected after infection. When the leaves of the resistant strains are compared with those of the susceptible ones of the same age, the resistant strains are characterized by higher sugar content than the susceptible ones. The results obtained suggest that the difference in sugar content must be due to the constitutional peculiarities of the resistant and the susceptible plants.

Still another possibility to be considered is the rate of translocation of the sugar from the leaves to other parts of the plants, for it might be that the movement of materials proceeds at a greater rate in the vegetatively more vigorous susceptible plants than in the resistant plants. If this supposition were correct, one would have to view the low sugar of the luxuriant susceptible plants, in contrast to the high sugar of the smaller, less rapidly growing resistant plants, as due to the removal of sugar to growing points and to ripening fruits. After all parts of the plant had come to maturity, the differ-

TABLE 17.—*Determination of carbohydrates in the leaves of different strains of Oenothera.*

[Percentage of dry weight.]

Key No.	Name of strain.	Characteristic of strain.	Year of collection.	Total sugar by acid hydrolysis.	Free reducing sugar.	Reducing sugar freed by hydrolysis.	Pentosans.	Starch.
1	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	1920	8.34	6.14	2.20	7.21	4.65
1a			1921	9.65	8.62	1.03	7.59	5.10
1b			1922	13.82	12.73	1.09	-----	-----
2	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	1920	8.17	6.66	1.51	6.39	4.37
2a			1921	5.18	4.55	0.63	6.99	4.80
2b			1922	8.79	8.43	0.36	-----	-----
3	*Oe. pratincola* hyb. *immunis*	Resistant	1920	12.68	7.44	5.24	7.80	5.03
3a			1921	6.02	5.05	0.97	7.84	5.68
3b			1922	10.62	10.23	0.39	-----	-----
4	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	1920	9.42	6.93	2.49	6.55	4.87
4a			1921	2.79	2.17	0.62	7.40	4.32
4b			1922	7.58	7.20	0.38	-----	-----
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis*	Resistant	1920	7.81	6.76	1.05	7.45	4.95
5a			1921	4.73	4.23	0.50	8.10	3.95
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis*	Susceptible	1920	8.28	6.97	1.31	6.50	4.78
6a			1921	4.34	4.18	0.16	7.00	3.48
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	1921	7.33	6.93	0.40	8.14	5.23
8a			1922	9.85	8.41	1.44	-----	-----
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	1921	6.85	6.53	0.31	6.63	5.10
9a			1922	6.40	5.79	0.61	-----	-----
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis*	do	1920	10.37	7.44	2.93	6.80	4.32
17b			1922	2.66	1.82	0.84	-----	-----
18	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago"*	do	1920	10.72	8.75	1.97	6.88	4.57
18b			1922	2.30	1.97	0.33	-----	-----
29a	*Oe. pratincola* hyb. *immunis*	Resistant	1922	9.90	9.58	0.42	8.36	-----
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	1922	8.27	7.62	0.65	8.24	-----
35	*Oe. "biennis Chicago"*	do	1922	6.25	5.34	0.91	8.06	-----

TABLE 18.—*Determination of sugar in the leaves of different strains of Oenothera collected at two different periods of growth during 1922.*

Key No.	Name of strain.	Date of collection.	Condition of strain during collection.	Total sugar by acid hydrolysis.	Free reducing sugar.	Reducing sugar freed by hydrolysis.
				Per cent.	*Per cent.*	*Per cent.*
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	July 19	No mildew	11.37	10.51	0.86
		August 30	do	13.82	12.73	1.09
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	July 19	do	8.79	8.43	0.36
		August 30	Mildew	10.56	9.37	1.19
3b	*Oe. pratincola* hyb. *immunis*	July 5	No mildew	10.62	10.23	0.39
		August 31	do	10.64	10.04	0.60
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	July 5	do	7.58	7.20	0.38
		August 31	Mildew	7.58	6.75	0.83
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	July 5	No mildew	11.20	10.63	0.57
		August 30	do	9.85	8.41	1.44
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	July 5	do	3.71	2.99	0.72
		August 30	Mildew	6.40	5.79	0.61
29a	*Oe. pratincola* hyb. *immunis*	July 6	No mildew	17.32	16.66	0.66
		August 28	do	9.90	9.58	0.42
34	*Oe. pratincola* hyb. *rubricalyx*	July 5	do	8.16	7.56	0.60
		August 28	Mildew	8.27	7.62	0.65
35	*Oe.* "*biennis Chicago*"	July 5	No mildew	8.10	7.70	0.40
		August 28	Mildew	6.25	5.34	0.91

ence should cease to exist. The results are not inconsistent with this hypothesis which, to be proved, would require elaborate experimentation. In any event, it would remain true that the low sugar of the susceptible strains is a constitutional peculiarity, and not due to modification by the mildew.

With respect to the pentosan in the leaves, Table 17 seems to show that the resistant strains contain more than the susceptible ones. However, when the determination was extended to other strains (see Table 19), it was found that pairs of reciprocal hybrids in which both members are susceptible may also show a high pentosan content. Consequently, the results do not permit any possible interpretation. One significant feature of the pentosan determination, however, is that strains similar in genetic composition also have nearly the same percentage of pentosan. This can be noticed in crosses between *Oe. mississippiensis* and *Oe. cinerescens* where one of the hybrids is a metaclinic (key Nos. 13a and 14).

The amount of starch in the leaves of the resistant and the susceptible strains does not differ considerably.

TABLE 19.—*Determination of pentosans in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Pentosans in 1920.	Pentosans in 1921.
			Per cent.	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	7.21	----------
1a			----------	7.59
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	6.89	----------
2a			----------	6.99
3	*Oe. pratincola* hyb. *immunis*	Resistant	7.80	----------
3a			----------	7.84
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	6.55	----------
4a			----------	7.40
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*	Resistant	7.45	----------
5a			----------	8.10
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis.*	Susceptible	6.60	----------
6a			----------	7.00
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.*	Resistant	----------	8.14
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens.*	Susceptible	----------	6.68
10	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis.*	Resistant	7.56	----------
11	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago."*	Susceptible	6.91	----------
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	----------	7.97
14	*Oe. cinerescens* × *Oe. mississippiensis,* metaclinic hybrid.	do	----------	8.29
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx.*	do	6.80	----------
17a			----------	7.80
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	6.88	----------
18a			----------	7.24
19a	*Oe. mississippiensis* × *Oe. "biennis Chicago."*	do	----------	6.80
21a	*Oe. "biennis Chicago" Oe. mississippiensis*	do	----------	7.61
22a	*Oe. mississippiensis* × *Oe. pratincola* hyb. *rubricalyx.*	do	----------	8.11
23a	*Oe. pratincola* hyb. *rubricalyx* × *Oe. mississippiensis.*	do	----------	6.82
24	*Oe. pratincola* mut. *nitidissima*	Resistant	----------	7.82
24a	do	do	----------	7.90
25	do	Susceptible	----------	7.22
25a	do	do	----------	7.18
29a	*Oe. pratincola* hyb. *immunis*	Resistant	----------	8.86
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	----------	8.24
35	*Oe. "biennis Chicago"*	do	----------	8.06

THE TANNIN

In the determination of the sugar, it was noticed that the amount of Fehling's solution reduced by the unclarified extract of the leaves was much higher than that for the same extract after it was clarified with lead subacetate solution. Another striking thing was that the unclarified extract of the resistant strains showed higher reduction than that of the susceptible ones. Table 20 shows the results alluded to. It was obvious that there must be in the extract some substance other than sugar that possessed the power of reducing Fehling's solution and that differed from sugar in being precipitated by the lead subacetate. It could not be a glucoside of the usual type, for the high reduction of Fehling's solution was noticed in the extract before hydrolysis. Moreover, the percentage of reducing sugar freed by hydrolysis does not differ very much in the clarified and the unclarified extracts. The extract when tested with ferric chloride solution gave a deep blackish blue color, suggesting that tannin must be the other substance in the extract which reduced the Fehling's solution and was precipitated with lead subacetate. Accordingly, a tannin determination was carried out for a number of strains and the results in Table 21 are in accordance with the expectation. Some characteristic features that are shown in the table are:

1. In pairs of reciprocal hybrids, the resistant one contains a much higher percentage of tannin than the susceptible one, the difference varying from 50 to 150 per cent.

2. Those elementary species which are resistant have higher tannin content than those which are susceptible, the only exception being *Oe. "biennis Chicago,"* a susceptible species in which the tannin is rather high.

3. Of pairs in which both reciprocal hybrids are susceptible, the tannin content is correspondingly low.

4. The metaclinic hybrid *Oe. cinerescens* × *Oe. mississippiensis* and its reciprocal are found to contain almost the same amount of tannin.

5. Of the two strains of *Oe. pratincola* mut. *nitidissima* the resistant one is higher in tannin than the susceptible one.

THE CRUDE FIBER

The determinations of crude fiber that are given in Table 22 indicate that the resistant strains have higher crude fiber than the susceptible ones.

THE WATER-SOLUBLE ACIDS

There is a much greater amount of water-soluble acid in the leaves of the resistant hybrids than in the leaves of those which are susceptible (see Table 23). In the elementary species, the resistant ones are also conspicuously higher in total acid.

TABLE 20.—*Reducing sugar in the leaves of the different strains of Oenothera.*

[Percentage of dry weight.]

Key No.	Name of strain.	Characteristic of strain.	Year of collection.	Clarified solution.			Unclarified solution.		
				Reducing sugar before inversion.	Reducing sugar after inversion.	Reducing sugar freed by hydrolysis.	Reducing sugar before inversion.	Reducing sugar after inversion.	Reducing sugar freed by hydrolysis.
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	1920	6.14	8.34	2.20	18.27	20.63	2.36
1a			1921	8.62	9.65	1.03	21.70	22.64	0.94
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	1920	6.66	8.17	1.51	13.60	15.95	2.35
2a			1921	4.55	5.18	0.63	12.22	13.56	1.34
3	*Oe. pratincola* hyb. *immunis*	Resistant	1920	7.44	12.68	5.24	18.05	23.07	5.02
3a			1921	5.05	6.02	0.97	18.63	20.81	2.18
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	1920	6.93	9.42	2.49	15.69	20.18	4.49
4a			1921	2.17	2.79	0.62	10.27	11.29	1.02
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis*.	Resistant	1920	6.76	7.81	1.05	16.41	18.84	2.43
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis*.	Susceptible	1920	6.97	8.28	1.31	13.47	15.49	2.07
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	1921	6.93	7.33	0.40	15.03	16.87	1.84
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	1921	6.53	6.85	0.31	11.46	12.90	1.44
17	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *rubricalyx*.	do	1920	7.44	10.37	2.93	21.24	24.04	2.80
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago"*.	do	1920	8.75	10.72	1.97	18.46	20.35	1.89

In the case of the strains that have the same zygotic composition as far as their reaction with the mildew is concerned, the percentage of the water-soluble acid does not differ to a great extent. This is shown by the metaclinic hybrid *Oe. cinerescens* × *Oe. mississippiensis* and its reciprocal. The parent species exhibit the same characteristic as their corresponding hybrids. For example, the water-soluble content in the resistant *Oe. pratincola* hyb. *immunis* is almost twice as high as in *Oe. pratincola* hyb. *rubricalyx*, a susceptible parent.

TABLE 21.—*Percentage of tannin in the leaves of different strains of Oenothera.*

[Expressed in terms of gallotanic acid.]

Key No.	Name of strain.	Characteristic of strain.	Tannin in 1920.	Tannin in 1921.	Tannin in 1922.
			Per cent.	*Per cent.*	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	13.24	--------	--------
1a			--------	10.08	--------
1b			--------	--------	9.87
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	5.06	--------	--------
2a			--------	3.47	--------
2b			--------	--------	5.05
3	*Oe. pratincola* hyb. *immunis*	Resistant	8.96	--------	--------
3a			--------	9.79	--------
3b			--------	--------	10.22
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	5.41	--------	--------
4a			--------	5.43	--------
4b			--------	--------	6.22
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*	Resistant	6.87	--------	--------
5a			--------	6.58	--------
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis.*	Susceptible	3.83	--------	--------
6a			--------	4.49	--------
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.*	Resistant	--------	5.49	--------
8a			--------	--------	8.30
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens.*	Susceptible	--------	2.22	--------
9a			--------	--------	3.58
10	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis.*	Resistant	9.27	--------	--------
11	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago."*	Susceptible	4.41	--------	--------
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	--------	3.94	--------
13b			--------	--------	5.83
14	*Oe. cinerescens* × *Oe. mississippiensis*, metaclinic hybrid.	do	--------	3.54	--------
14a			--------	--------	5.19
17	*Oe. "biennis Chicago"* × *Oe. pranticola* hyb. *rubricalyx.*	do	9.14	--------	--------
17a			--------	6.82	--------
17b			--------	--------	9.42
18	*Oe. pratincola* hyb. *rubricalyx* × *Oe. "biennis Chicago."*	do	6.30	--------	--------
18a			--------	8.52	--------
18b			--------	--------	9.84
22	*Oe. mississippiensis* × *Oe. pratincola* hyb. *rubricalyx.*	do	6.09	--------	--------
22a			--------	4.99	--------

TABLE 21.—*Percentage of tannin in the leaves of different strains of Oenothera*—Continued.

Key No.	Name of strain.	Characteristic of strain.	Tannin in 1920.	Tannin in 1921.	Tannin in 1922.
			Per cent.	*Per cent.*	*Per cent.*
23	*Oe. pratincola* hyb. *rubricalyx* × *Oe. mississippiensis.*	Susceptible	6.77	--------	--------
23a			-------	5.35	--------
24	*Oe. pratincola* mut. *nitidissima*	Resistant	--------	10.96	--------
24a	do	do	--------	11.12	--------
25	do	Susceptible	--------	8.66	--------
26	*Oe. numismatica*	Resistant	--------	12.74	--------
27	*Oe. pratincola* mut. *simulans*	do	--------	10.06	--------
28	*Oe. pratincola* mut. *simulans rubricalyx*	Susceptible	--------	8.68	--------
29	*Oe. pratincola* hyb. *immunis*	Resistant	-------	9.95	--------
29a			-------	--------	10.48
30	*Oe. reynoldsii* × *Oe. pratincola*	do	--------	8.82	--------
31	*Oe. pratincola* (susceptible)	Susceptible	--------	6.19	--------
32	*Oe. mississippiensis*	do	--------	6.99	--------
33	*Oe. reynoldsii*	Resistant	--------	11.03	--------
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	-------	--------	5.10
35	*Oe. "biennis Chicago"*		-------	--------	10.85

TABLE 22.—*Determination of crude fiber in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Crude fiber in 1920.	Crude fiber in 1921.
			Per cent.	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	7.77	---------
1a			---------	6.02
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	5.60	---------
2a			---------	5.85
3	*Oe. pratincola* hyb. *immunis*	Resistant	6.41	---------
3a			---------	6.49
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	5.43	---------
4a			---------	6.15
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*	Resistant	7.26	---------
5a			---------	7.45
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis.*	Susceptible	6.39	---------
6a			---------	6.80
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	---------	7.29
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	---------	6.19
24	*Oe. pratincola* mut. *nitidissima*	Resistant	---------	7.12
24a	do	do	---------	7.33
25	do	Susceptible	---------	6.53
25a	do	do	---------	6.41

THE TOTAL ASH

The results of the total ash determination in Table 24 indicate that, with a few exceptions, the susceptible strains contain much more total ash than the resistant ones. Exceptions were noted in hybrids resulting from *Oe. mississippiensis* and *Oe. pratincola* hyb. *immunis, Oe. "biennis Chicago"* and *Oe. pratincola* hyb. *immunis,* and *Oe. cinerescens* and *Oe. mississippiensis.* However, in these exceptional cases the percentage of total ash in the resistant hybrids is only slightly higher than in their susceptible reciprocals.

TABLE 23.—*Determination of the water-soluble acid in the leaves of different strains of Oenothera.*

[Expressed in milligrams of sodium hydroxide required to neutralize the acid from 1 gram of moisture-free leaves.]

Key No.	Name of strain.	Characteristic of strain.	1920	1921	1922
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	37.56	-------	-------
1a			-------	25.21	-------
1b			-------	-------	21.61
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	25.36	-------	-------
2a			-------	20.65	-------
2b			-------	-------	17.24
3	*Oe. pratincola* hyb. *immunis*	Resistant	24.16	-------	-------
3a			-------	23.28	-------
3b			-------	-------	25.60
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	23.12	-------	-------
4a			-------	21.92	-------
4b			-------	-------	19.28
5	*Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*	Resistant	30.04	-------	-------
5a			-------	20.02	-------
6	*Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis.*	Susceptible	24.16	-------	-------
6a			-------	21.96	-------
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.*	Resistant	-------	21.36	-------
8a			-------	-------	19.52
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens.*	Susceptible	-------	13.72	-------
9a			-------	-------	13.68
10	*Oe. "biennis Chicago"* × *Oe. pratincola* hyb. *immunis.*	Resistant	32.04	-------	-------
11	*Oe. pratincola* hyb. *immunis* × *Oe. "biennis Chicago."*	Susceptible	25.24	-------	-------
12	*Oe. cinerescens* × *Oe. mississippiensis*	Resistant	24.64	-------	-------
13	*Oe. mississippiensis* × *Oe. cinerescens*	Susceptible	23.84	-------	-------
13a			-------	14.72	-------
13b			-------	-------	18.64
14	*Oe. cinerescens* × *Oe. mississippiensis,* metaclinic hybrid.	do	-------	13.44	-------
14a			-------	-------	18.26
24	*Oe. pratincola* mut. *nitidissima*	Resistant	-------	30.40	-------
24a	do	do	-------	31.64	-------
25	do	Susceptible	-------	26.72	-------
25a	do	do	-------	27.15	-------
29a	*Oe. pratincola* hyb. *immunis*	Resistant	-------	-------	23.85
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	-------	-------	12.43
35	*Oe. "biennis Chicago"*	do	-------	-------	19.15

THE INORGANIC CONSTITUENTS OF THE ASH

In order to find out the constituents of the ash that differ to a marked degree in the resistant and the susceptible strains, partial ash analyses were made. The results, given in Table 25, reveal that the main difference is found in the calcium and sulphur content. The percentages of these two elements are higher in the leaves of the susceptible strains than in those of the resistant ones. To a small degree the susceptible strains also contain more phosphorus and potassium. When the different constituents are expressed as percentages of the total ash (Table 26), the results for potassium and phosphorus are not concordant, while those for calcium and sulphur are; that is, the total ash of the susceptible strains contains more calcium and sulphur than does that of the resistant ones.

In view of the marked differences noted in the percentage of total nitrogen, total ash, sugar, tannin, and water-soluble acid in the resistant and the susceptible strains, further analyses were made to see if these differences existed in the plants before the susceptible strains were mildewed. These five constituents were, therefore, determined in the leaves of several strains collected at two different periods of growth; one when the susceptible strains were not yet infected, and the other when they were infected. The results in Table 27 show some interesting facts. In the first place, the characteristic chemical differences between the resistant and the susceptible strains are found to be exactly the same, both before and after infection. In fact, the differences are even more pronounced before infection, for the resistant strains are exceedingly high in tannin and water-soluble acid, while the susceptible ones contain a great amount of total ash and total nitrogen. Another point of interest is that the amounts of the total nitrogen, tannin, total ash, and water-soluble acid do not differ much for the two periods in the resistant strains; whereas, in the susceptible, the percentage of these four constituents varies considerably for the two periods, the variation being in such direction as to render their difference from the resistant ones far more significant. The results obtained for the sugar have already been presented separately in Table 18, in connection with the carbohydrates.

EXTENSION OF THE WORK TO OTHER PLANTS

To determine whether the chemical differences existing in the different strains of *Oenothera* are also found in other

TABLE 24.—*Percentage of total ash in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Total ash in 1920.	Total ash in 1921.	Total ash in 1922.
			Per cent.	*Per cent.*	*Per cent.*
1	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	11.09	--------	--------
1a			--------	9.04	--------
1b			--------	--------	8.77
2	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	13.40	--------	--------
2a			--------	13.14	--------
2b			--------	--------	11.16
3	*Oe. pratincola* hyb. *immunis*	Resistant	11.29	--------	--------
3a			--------	9.57	--------
3b			--------	--------	10.81
4	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	13.10	--------	--------
4a			--------	13.28	--------
4b			--------	--------	13.93
5	*Oe. mississippiensis* X *Oe. pratincola* hyb. *immunis.*	Resistant	11.27	--------	--------
5a			--------	12.81	--------
6	*Oe. pratincola* hyb. *immunis* X *Oe. mississippiensis.*	Susceptible	10.16	--------	--------
6a			--------	12.06	--------
8	*Oe. cinerescens* X *Oe. pratincola* hyb. *immunis.*	Resistant	--------	10.65	--------
8a			--------	--------	11.58
9	*Oe. pratincola* hyb. *immunis* X *Oe. cinerescens.*	Susceptible	--------	13.54	--------
9a			--------	--------	15.03
10	*Oe. "biennis Chicago"* X *Oe. pratincola* hyb. *immunis.*	Resistant	11.90	--------	--------
11	*Oe. pratincola* hyb. *immunis* X *Oe. "biennis Chicago."*	Susceptible	11.49	--------	--------
12	*Oe. cinerescens* X *Oe. mississippiensis*	Resistant	13.63	--------	--------
13	*Oe. mississippiensis* X *Oe. cinerescens*	Susceptible	13.49	--------	--------
13a			--------	13.66	--------
13b			--------	--------	14.83
14	*Oe. cinerescens* X *Oe. mississippiensis,* metaclinic hybrid.	do.	--------	14.00	--------
14b			--------	--------	14.68
15	*Oe. pratincola* X *Oe. reynoldsii* (*Oe. pratincola* hyb. *amycosa*).	Resistant	10.84	--------	--------
16	*Oe. reynoldsii* X *Oe. pratincola*	Susceptible	11.26	--------	--------
17a	*Oe. "biennis Chicago"* X *Oe. pratincola* hyb. *rubricalyx.*	do.	--------	11.18	--------
17b			--------	--------	11.08
18	*Oe. pratincola* hyb. *rubricalyx* X *Oe. "biennis Chicago".*	do.	--------	11.73	--------
18a			--------	--------	12.96
24	*Oe. pratincola* mut. *nitidissima*	Resistant	--------	10.44	--------
24a	do.	do.	--------	9.97	--------
25	do.	Susceptible	--------	11.88	--------
25a	do.	do.	--------	11.10	--------
26	*Oe. numismatica*	Resistant	--------	9.76	--------
27	*Oe. pratincola* mut. *simulans*	do.	--------	10.63	--------
28	*Oe. pratincola* mut. *simulans rubricalyx*	--------	--------	11.39	--------
29a	*Oe. pratincola* hyb. *immunis*	Resistant	--------	--------	7.47
31	*Oe. pratincola*	Susceptible	--------	12.94	--------
32	*Oe. mississippiensis*	do.	--------	11.51	--------
33	*Oe. reynoldsii*	Resistant	--------	10.60	--------
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	--------	--------	13.04
35	*Oe. "biennis Chicago"*	do.	--------	--------	11.55

TABLE 25.—*Constituents of the ash in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Total ash.	Constituents of ash, expressed as percentage of moisture-free leaves.						
				SiO_2	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	8.77	0.346	3.32	1.04	0.713	0.139	0.425	0.541
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	11.16	0.414	4.51	1.10	1.07	0.134	0.628	0.875
3b	*Oe. pratincola* hyb. *immunis*	Resistant	10.81	0.445	4.24	1.07	1.08	0.088	0.560	0.763
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	13.93	0.549	5.87	1.36	11.36	0.048	0.663	1.067
8a	*Oe. cinerescens* X *Oe. pratincola* hyb. *immunis.*	Resistant	11.58	0.325	4.47	1.25	1.21	0.086	0.558	0.867
9a	*Oe. pratincola* hyb. *immunis* X *Oe. cinerescens.*	Susceptible	15.03	0.387	6.80	1.39	1.41	0.052	0.688	1.99
29a	*Oe. pratincola* hyb. *immunis*	Resistant	7.47	0.217	2.66	0.677	0.702	0.044	0.391	0.508
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	13.04	0.539	5.01	1.48	1.64	0.177	0.633	1.17

TABLE 26.—*Constituents of the ash in the leaves of different strains of Oenothera.*

Key No.	Name of strain.	Characteristic of strain.	Expressed as percentage of total ash.						
			SiO_2	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3
1b	Resistant *Oe. pratincola* (a segregate from species hybrid).	Resistant	3.94	37.81	11.59	8.13	1.59	4.85	6.18
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.71	40.45	9.89	9.61	1.20	5.63	7.85
3b	*Oe. pratincola* hyb. *immunis*	Resistant	4.12	39.26	10.35	10.02	0.812	5.18	7.06
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid).	Susceptible	3.94	42.15	9.78	9.74	0.342	4.76	7.65
8a	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	2.81	38.61	10.76	10.46	0.745	4.82	7.48
9a	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	2.58	45.25	9.24	9.37	0.348	4.58	13.23
29a	*Oe. pratincola* hyb. *immunis*	Resistant	2.90	35.61	9.07	9.40	0.590	5.24	6.71
34	*Oe. pratincola* hyb. *rubricalyx*	Susceptible	4.13	38.41	11.32	12.54	1.36	4.86	8.96

TABLE 27.—*Total nitrogen, tannin, total ash, and water-soluble acid in the leaves of different strains of Oenothera collected at two different periods of growth during 1922.*

Key No.	Name of strain.	Date of collection.	Condition of strain during collection.	Total nitrogen.	Tannins.	Total ash.	Water-soluble acid in terms of mgm. NaOH.[a]
				Per cent.	*Per cent.*	*Per cent.*	
1b	Resistant *Oe. pratincola* (a segregate from species hybrid)	July 19	No mildew	2.40	10.80	8.21	30.32
		August 30	do	2.54	9.87	8.77	21.61
2b	Mildewed *Oe. pratincola* (a segregate from species hybrid)	July 19	do	3.63	4.30	12.70	21.28
		August 30	Mildew	3.03	5.05	11.16	17.24
3b	*Oe. pratincola* hyb. *immunis*	July 6	No mildew	2.06	10.85	7.54	26.36
		August 30	do	2.29	10.22	10.81	25.60
4b	Mildewed *Oe. pratincola* (a segregate from species hybrid)	July 6	do	3.86	3.98	14.19	17.24
		August 30	Mildew	3.08	6.22	13.93	19.28
8a	*Oe. cinerescens* ×	July 6	No mildew	2.54	9.30	10.19	26.48
	Oe. pratincola hyb. *immunis*	August 30	do	2.45	8.30	11.58	19.52
9a	*Oe. pratincola* hyb. *immunis* ×	July 6	do	3.94	2.38	16.57	17.76
	Oe. cinerescens	August 30	Mildew	2.81	3.58	15.03	13.68
13b	*Oe. mississippiensis* ×	July 6	No mildew	3.81	5.56	15.12	20.88
	Oe. cinerescens	August 30	Mildew	2.69	5.83	14.83	18.64
14a	*Oe. cinerescens* ×	July 6	No mildew	3.67	5.71	14.72	20.80
	Oe. mississippiensis, metaclinic hybrid	August 30	Mildew	2.64	6.19	14.68	18.26
29a	*Oe. pratincola* hyb. *immunis*	July 6	No mildew	2.31	10.69	7.75	25.68
		August 28	do	2.54	10.48	7.47	23.85
34	*Oe. pratincola* hyb. *rubricalyx*	July 6	do	3.84	2.46	14.65	13.96
		August 28	Mildew	2.95	5.10	13.04	12.43
35	*Oe.* "*biennis Chicago*"	July 5	No mildew	3.49	5.47	12.89	21.20
		August 28	Mildew	2.91	10.85	11.55	19.15

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[a] The water-soluble acid is expressed as the number of milligrams of sodium hydroxide required to neutralize the acid from 1 gram of moisture-free leaves.

plants that are infected by other forms of powdery mildew, the determination for total nitrogen, total ash, tannin, and water-soluble acid was extended to *Syringa vulgaris, Desmodium canadensis, Helianthus giganteus,* and *Solidago canadensis,* all of these plants having been found to have resistant and susceptible varieties. The results of the determination are given in Table 28. Except for the total ash and water-soluble acid of the strains of *Helianthus giganteus,* the findings confirm those already found in *Oenothera.* There was little time available for this work, which was undertaken through curiosity and with the knowledge that it could not be carried far. It indicates that the results for *Oenothera* are probably of general applicability, and that any of the foregoing genera, and doubtless many others, would afford material that would be equally interesting from the standpoint of genetics and disease resistance in *Oenothera.*

TABLE 28.—*Total nitrogen, tannin, total ash, and water-soluble acid (in terms of NaOH required for neutralization of acid from 1 gram of moisture-free leaves) in the leaves of some plants which were found during the summer of 1922 to have strains resistant and susceptible to powdery mildew.*

Name of plant.	Characteristic of plant.	Total nitrogen.	Total tannin.	Total ash.	Water-soluble acid mgm. NaOH.
		Per cent.	*Per cent.*	*Per cent.*	
Syringa vulgaris	Highly resistant	1.99	2.52	9.93	13.40
Do	Susceptible	2.68	1.40	12.48	10.08
Desmodium canadensis	Resistant	2.88	4.39	7.32	11.24
Do	Susceptible	2.95	2.06	8.51	10.92
Helianthus giganteus	Resistant	1.98	6.36	17.93	7.16
Do	Susceptible	2.36	5.98	11.57	7.12
Solidago canadensis	Resistant	2.43	0.85	10.62	11.40
Do	Susceptible	2.76	0.003	12.47	8.48

DISCUSSION OF RESULTS

The whole body of experimental data brought forward indicates that the chemical differences between the resistant and the susceptible strains of *Oenothera* are definite hereditary characteristics, and that these chemical characteristics are correlated with the degree of resistance of the various strains to mildew. This statement holds true for the nitrogen distribution, the tannin, the water-soluble acid, and the total ash. Therefore, it is possible, if the analysis of a strain is given, to predict more or less accurately what the reaction to mildew will be. It is not possible, however, to use the percentage of any one constituent as an unfailing index. When the results of analysis are expressed as percentages it is obvious that, if one constituent is high, other constituents must be correspondingly low. A series of ratios, in which some one constituent is taken as unity, indicates more clearly than does the percentage composition the significance of variation in single constituents. Such ratios, for example, show at a glance whether or not two strains differing in percentage composition have actually the same relative composition except with regard to one constituent. For example, if the total nitrogen content of all strains under consideration is considered as unity, the ratios of the various constituents may be summarized for comparison at a glance, as in Table 29.

In Table 29 the ratios show a correlation or at least a parallelism of only two constituents, namely, total nitrogen and total ash. There seems to be no consistent quantitative interdependence among the other constituents, except that pentosan and water-soluble acid show parallel variation. The ratios with constituents other than total nitrogen taken as unity are shown in Tables 30 to 33.

If the amount of any one constituent alone determined resistance or susceptibility, one might expect to find all the other constituents showing parallel variation such as we find in the case of total nitrogen and total ash, or perhaps nonconcordant variation in several pairs of reciprocals. The former condition might be expected in forms morphologically identical but different physiologically, as indicated by unlike resistance to infection. The latter condition would be expected in morphologically unlike strains as well as in those physiologically unlike, since of course one would expect structural dissimilarities of considerable magnitude to be reflected in some way in the chemical composition. Nothing is more obvious from an examination of the tables, however, than that every resistant strain is higher in tannin and water-soluble acid than the genetically most closely related susceptible strain which may be compared with it. Conversely, the resistant strains are correspondingly low in total nitrogen and ash. The results for sugar are not concordant.

Our results, therefore, fail to point to any single constituent as the basis for resistance, and we are justified in concluding only that, when an *Oenothera* is low in nitrogen and ash and high in tannin and acid, it is a resistant strain; if the situation is reversed, the strain is susceptible. As far as we can draw conclusions from the results, we may look upon resistance as having several or many contributory factors.

TABLE 29.—*Constitution of reciprocal hybrids and mutations of Oenothera, expressed as ratios, total nitrogen being taken as unity.*

Key No.	Name of strain.	Characteristic of strain.	Total nitrogen.	Pentosan.	Total sugar by acid hydrolysis.	Tannin.	Water-soluble acid.	Total ash.
1a	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	100	293 05	372.59	389.19	973.36	349.03
2a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	193.62	143.49	96.12	572.00	363.98
3a	*Oe. pratincola* hyb. *immunis*	Resistant	100	281.00	181.00	350.89	834.40	342.98
4a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	191.21	56.07	140.31	566.39	343.14
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	100	252.79	227.63	168.94	663.33	330.74
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	100	181.64	187.67	60.82	375.89	370.96
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	100	272.01		134.47	502.38	466.62
14	*Oe. cinerescens* × *Oe. mississippiensis*, metaclinic hybrid	do	100	289.86		123.78	469.93	489.51
24	*Oe. pratincola* mut. *nitidissima*	Resistant	100	280.28		392.83	1,089.59	374.19
25	do	Susceptible	100	225.62		274.05	845.55	375.94

TABLE 30.—*Constitution of reciprocal hybrids and mutations of Oenothera, expressed as ratios, total ash being taken as unity.*

Key No.	Name of strain.	Characteristic of strain.	Total ash.	Pentosan.	Total nitrogen.	Total sugar by acid hydrolysis.	Tannin.	Water-soluble acid.
1a	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	100	83.95	28.65	106.74	111.50	278.85
2a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	53.20	27.47	39.42	26.41	157.15
3a	*Oe. pratincola* hyb. *immunis*	Resistant	100	81.92	29.15	52.77	102.30	243.25
4a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	55.72	29.14	16.34	40.89	165.05
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	100	76.43	30.23	68.82	51.08	199.98
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	100	48.97	26.96	50.59	16.40	101.33
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	100	58.35	21.45		28.84	107.76

14	*Oe. cinerescens* × *Oe. mississippiensis*, metaclinic hybrid	do	100	59.21	20.43		25.29	95.99
24	*Oe. pratincola* mut. *nitidissima*	Resistant	100	74.90	26.72		104.98	291.17
25	do	Susceptible	100	60.02	26.59		72.90	224.92

TABLE 31.—*Constitution of reciprocal hybrids and mutations of Oenothera, expressed as ratios, pentosan being taken as unity.*

Key No.	Name of strain.	Characteristic of strain.	Pentosan.	Total nitrogen.	Total sugar by acid hydrolysis.	Tannin.	Water-soluble acid.	Total ash.
1a	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	100	34.11	127.09	132.75	332.02	119.06
2a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	51.64	74.11	49.64	295.42	187.98
3a	*Oe. pratincola* hyb. *immunis*	Resistant	100	35.59	64.41	127.87	296.94	122.07
4a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	52.30	29.32	73.38	296.20	179.45
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	100	39.56	90.05	66.83	262.41	130.84
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	100	55.05	103.31	33.48	206.93	204.21
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	100	36.76		49.44	184.69	171.39
14	*Oe. cinerescens* × *Oe. mississippiensis*, metaclinic hybrid	do	100	34.50		42.70	162.11	168.87
24	*Oe. pratincola* mut. *nitidissima*	Resistant	100	35.68		140.15	388.72	133.50
25	do	Susceptible	100	44.32		121.46	374.75	166.62

TABLE 32.—*Constitution of reciprocal hybrids and mutations of Oenothera, expressed as ratios, tannin being taken as unity.*

Key No.	Name of strain.	Characteristic of strain.	Tannin.	Pentosan.	Total nitrogen.	Total sugar by acid hydrolysis.	Water soluble acid.	Total ash.
1a	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	100	75.30	25.69	95.73	250.09	89.68
2a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	201.44	104.03	149.28	595.09	378.67
3a	*Oe. pratincola* hyb. *immunis*	Resistant	100	80.08	28.49	51.58	237.78	97.75
4a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	136.29	71.27	39.96	403.68	244.56
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	100	149.63	59.19	134.74	392.64	195.77
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	100	298.65	164.41	308.56	618.02	609.91
13a	*Oe. mississippiensis* × *Oe. cinerescens*	do	100	202.28	74.36		373.59	346.69
14	*Oe. cinerescens* × *Oe. mississippiensis*, metaclinic hybrid	do	100	234.18	80.79		379.65	395.47
24	*Oe. pratincola* mut. *nitidissima*	Resistant	100	71.35	25.46		277.37	95.25
25	do	Susceptible	100	82.33	36.49		308.54	137.18

TABLE 33.—*Constitution of reciprocal hybrids and mutations of Oenothera, expressed as ratios, sugar being taken as unity.*

Key No.	Name of strain.	Characteristic of strain.	Total sugar by acid hydrolysis.	Pentosan.	Total nitrogen.	Tannin.	Water soluble acid.	Total ash.
1a	Resistant *Oe. pratincola* (a segregate from species hybrid)	Resistant	100	78.65	26.83	104.45	261.12	93.67
2a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	134.94	69.69	66.99	398.65	253.67
3a	*Oe. pratincola* hyb. *immunis*	Resistant	100	155.24	55.25	193.85	460.97	189.50
4a	Mildewed *Oe. pratincola* (a segregate from species hybrid)	Susceptible	100	341.00	178.34	250.23	1,010.12	611.97
8	*Oe. cinerescens* × *Oe. pratincola* hyb. *immunis*	Resistant	100	111.05	43.93	74.21	291.39	145.29
9	*Oe. pratincola* hyb. *immunis* × *Oe. cinerescens*	Susceptible	100	96.79	53.28	32.41	200.28	197.66

In *Oenothera* it is well known that whole groups of morphological characters cohere strongly in inheritance. The explanation of the phenomenon is still a matter for investigation. Geo. H. Shull (44) thinks that he has reached a basis for an explanation in his hypothesis that the factorial differences between the various *Oenothera* strains in the congeries of elementary species and hybrids grouped about *Oe. biennis, Oe. pratincola, Oe. lamarckiana,* etc., are located in a single chromosome. Therefore, all factorial complexes are hereditary as a whole, except as crossing-over may occur. A more conservative hypothesis is that of Bartlett and of Cobb and Bartlett, (5, 10) according to whom the peculiarities of inheritance in *Oenothera* need not necessarily be viewed as dependent upon all the mutable factors being located in a single chromosome. On the contrary, several chromosomes may conceivably form a coherent group in the reduction division apart from a residue of other freely segregating chromosomes which are probably the bearers of typically Mendelian characteristics. The hypothesis thus briefly outlined is the one (called the α and β hypothesis) which has served for the formulation of the genetical data concerning the strains dealt with in this paper. It has been brought forward subsequently as something new by Lotsy, (29) who calls it the "Kernchimaera" hypothesis.

Without this slight digression the reader might misunderstand my conception of resistance to be that it is due to a complex of factors rather than a single factor. It is consistent with all that is known of the genetics of *Oenothera* for a factor complex to be inherited as a whole. Consequently, the breeding data are sharp and clear in a way that we seldom expect to find in other groups where the factors, which together contribute to immunity, are located in different chromosomes and, therefore, segregate freely from one another when hybridization takes place. In *Oenothera,* when a disease-resistant factor complex has once come about, the peculiarities of inheritance are such that it is not disintegrated even by hybridization; hence, the unusually sharp and simple relationships that have come to light with regard to inheritance. In plants with simpler, freely segregating Mendelian factors, one would expect very few cases in which clear-cut differences with regard to infection would prove to be due to a single Mendelian factor. The results with *Oenothera,* however, lead to the supposition that, if immunity is generally due to contributory and interacting factors, there is every reason why the plant breeder should work according to a consistent program for the accumulation in a single strain of all factors contributing to disease resistance. In such work the chemical composition of the plant breeder's basic materials might afford him a criterion for guidance during the process of building up a resistant factor complex. The biochemical study of geneticists' materials certainly cannot fail eventually to find important applications.

It is instructive to compare the analytical data for reciprocal hybrids with those for mutations that differ visibly from each other only in resistance. The two members of the several pairs of reciprocal hybrids were usually quite distinct from each other morphologically as well as in resistance. They were selected as material for this study because they show great contrast in immunity, and the analytical data show correspondingly strong contrasts. In the case of the mutations, two types were chosen that were morphologically alike and differed only in resistance. Although called *Oe. pratincola* mut. *nitidissima,* neither was of direct descent from the original mutation, but they were the *nitidissima* types splitting out of crosses with the parent species, *Oe. pratincola.* Factorial recombination brought about forms differing in resistance. Comparison of the analyses shows variations in chemical composition quite parallel with those differentiating the more diverse reciprocal hybrids, but of smaller magnitude.

Another very interesting fact is brought out in the comparison of one member of a pair of reciprocal hybrids with a morphologically identical metaclinic hybrid in the reciprocal cross. To illustrate how these metaclinic plants arise, let us take a hypothetical case of a cross between species A and B, of which the matroclinic, true-breeding first generation hybrids are A′ and B′. Then

$$A \times B \rightarrow A'$$
$$B \times A \rightarrow B'$$

In rare instances, however, the progeny consisting of hybrid A′ may contain individuals of hybrid B′ and, conversely, the progeny consisting of hybrid B′ may contain a few individuals of A′. These plants which appear to be out of place are called metaclinic hybrids by De Vries.(17) In some instances, notwithstanding morphological identity with the majority of plants in the reciprocal cross, they will be different as to immunity. In such cases there are likewise chemical differences, of the same direction for the same constituents, as in the resistant and nonresistant types of *Oe. pratincola* mut. *nitidissima.*

In connection with the relative differences found in chemical composition between susceptible and resistant strains of *Oenothera,* it is of interest to give a brief account of the modes of entrance of the hyphae and haustoria of the Erysipheae into the cells of the host. Salmon(41) states that—

> the ordinary vegetative mycelium consists of very numerous, delicate, white or colorless septate hyphæ, frequently branched and more or less densely interwoven. In all genera, except Phyllactinia, the hyphæ of the vegetative mycelium produce haustoria at intervals which pierce the cuticle and swell out into a bladder-like form in the epidermal cells. These haustoria serve both to attach the fungus to its host and draw nourishment from it.

Smith(45) describes the haustorium of the Erysiphae, in the specific case of *Erysiphe communis* on *Geranium maculatum,* as

> a slender, proximal portion, the neck, penetrating the epidermal wall of the cell, within which it enlarges into a vesicular, distal portion with a thin wall. On the interior, the vesicle is filled with a delicate, spongy protoplasm differing in no visible particulars from the protoplasm in the mycelium.

In *Oenothera,* according to Klaphaak and Bartlett,(27) the mildew *Erysiphe polygoni* DC. grows very superficially and the haustoria of the fungus extend into the epidermal cells. It is, therefore, the epidermal tissue that should be examined if the most nearly perfect correlation of chemical composition with resistance is to be discovered. The composition of the whole leaf can be of significance only if there is a correlation between the composition of the epidermis and the underlying tissues. Such a correlation I have assumed, and the results are so consistent throughout that there is no reason to question the validity of the assumption. If we visualize the epidermal cells as comparatively rich in tannin, sugar, and water-soluble acids, we must bear in mind that either the actual synthesis of these substances occurs in the green cells or else the substances from which they are synthesized come from the green cells. The equilibrium between the chemical content of the epidermal cells and that of the underlying tissues is of such a nature that we must suppose transposition of material to take place whenever the concentration of water-soluble substances changes. The epidermis, unable to carry on fundamental chemical synthesis, must be in the most intimate equilibrium with other tissues, and we should expect differences in epidermal content to be correlated with differences in the leaf as a whole.

The rôle of tannin has been studied extensively, both from the point of view of the metabolism of the host and from that of its influence on parasites. Here we are not concerned with the question whether tannin is regarded as a by-product of metabolism or as a reserve material. The point of importance is whether or not it prevents infection by mildew. The results of the earlier investigations in this regard are conflicting. Cook and Taubenhaus(13) were able to demonstrate that tannin is toxic to the growth of certain fungi, the parasitic forms being more sensitive than the saprophytic. Wehmer(54) found that the resistence of oak wood to dry rot is correlated with the amount of tannin in the wood. On the other hand, Valleau(55) obtained negative results in his attempt to relate tannin to the differences in resistance of varieties of plums to brown rot. Moreover, Willaman and Sandstrom(51) did not find significant differences in the tannin concentration of normal plums and the ones rotted by *Sclerotinia cinerea.* The conflicting results may be due to differences in the localization of tannin in different parts of a plant or plant organ. No fact is more familiar to the geneticist than the existence of factors which determine the distribution in certain cells of pigment, tannin, enzymes, etc. Such factors give rise to the color patterns of flowers and animals. In *Oenothera,* the results show no evidence of disturbance due to such factors, but plums might present entirely different conditions. Tannin localized elsewhere than in the epidermis would have no influence on infection by the fungus which grows superficially in plant tissue. Analysis of a whole fruit might show a high tannin content but, nevertheless, the fruit might have no resistance. When the difference of the tannin content between resistant and susceptible plants fails to correlate with resistance, it may be that the tannin is differently located. The action of tannin as a protective agent is summarized by Thatcher(47) in the following words:

> Either the tannin actually serves as an antiseptic to prevent the growth of the parasitic fungus within the tissues of the host plant, or it assists in the development of a corky layer which "walls-off" the infected area and so prevents further spread of the disease through the tissue.

The fact that tannin coagulates albumin and other proteins, suggests that it may be a protoplasmic poison. When the fungi are grown in synthetic media containing varying amounts of tannin, the harmful effect of the tannin is manifested in the majority of cases. However, if tannin is injurious to fungus protoplasm, why is it not also harmful to the protoplasm of the host plant? It is very likely that the protective effect of tannin in preventing the growth of parasitic fungi is conditioned by the other substances present in the cell sap. Thus De Dominicis (15) found that the coagulation of egg albumen by tannin can be prevented by the addition of acetic acid or tartaric acid, and that these two acids restore to its original condition an albumin which has been coagulated by tannin. Possibly in the tissues of a plant there are other substances besides the common acids which may serve to protect the protoplasm from the tannin of the same species. It is quite possible, however, that the foreign protoplasm of a parasitic fungus would be adversely affected by the same tannin. In this connection it is interesting to observe that an *Oenothera* that is high in tannin is likewise high in acid. Thus in the resistant strains we have a high tannin content, for which there is evidence of an immunizing function, coupled with a high acidity which is not inconceivably protective to the protoplasm. Thus an entire mechanism for resistance is present. Susceptible strains have a lesser development of the factorial complex for immunity, coupled with high water-soluble nitrogen which probably favors the nutrition of the mildew. One can hardly avoid the conclusion that striking differences in resistance are due to the interaction of various factors.

Most fungi grow best in slightly acid media but, when the concentration of acid is rather high, it inhibits growth. The cell-sap of the leaves of the resistant *Oenothera* is very high in acid which may influence the fungus adversely, quite aside from its possible protective influence in preventing coagulation of the proteins of the host protoplasm. The relation of acid content of the plant to disease resistance has been pointed out by many investigators. Comes (11) found that Rietti wheat, a very resistant variety, has a higher percentage of acid than other, susceptible varieties. Moreover, he also observed that, as the rust resistance of wheats increases with the altitude at which they are grown, their acid content is also correspondingly increased. Averna-Sacca (3) found that American grape and other plants which are highly resistant to the attacks of *Oidium peronospora* and gall mites are characterized by having a very high acid content. Brown (6) reported that the enzyme activity of an extract from *Botrytis cinerea* is inhibited by the addition of a fair amount of acid. The high concentration of acid in the leaves of the resistant *Oenothera* may be correlated with its resistance.

Turning now to the susceptible plants, we find that their nitrogen and ash content is high. Analyses of the constituents of total nitrogen and ash reveals further that, in the case of nitrogen, the form that predominates is the water-soluble nitrogen which, in turn, has a high concentration of amino acids and of nitrogenous compounds of nonbasic character. The ash contains a great deal of calcium and sulphur.

Zellner(57) found that Ascomycetes contain much protein but that the amount of tannin, if ever present, is extremely low. According to Pfeffer,(38) most fungi that are able to develop, in media containing nitrogen in the form of ammonium nitrate, grow better when supplied with peptone, amides, and other nitrogenous organic compounds. That the mildew on *Oenothera* probably derives its supply of nitrogen mainly from the water-soluble nitrogenous compounds in the leaves is sustained by the following experimental observation. When susceptible and resistant plants are examined at the period of their highest stage of growth, during which time the mildew on their leaves is also very active, the difference of nitrogen content between resistant and susceptible strains lies in the water-soluble nitrogen. In the same plants, examined at the time when they approach senility, the relative difference in nitrogen still persists but the consistent difference is found in the protein nitrogen. There are two possible explanations to account for this. One is that, during infection, the mildew is continually using some of the simple nitrogenous compounds, perhaps some of the amino acids, leaving other amino acids in excess, which are not immediately utilized for the synthesis of proteins. The equilibrium in the host may be looked upon as disturbed by the withdrawal of protein-forming substances in proportions different from those in which they are utilized in protein synthesis. In the senescent leaves, on the contrary, the mildew is no longer growing and the normal metabolism of the plants is not disturbed. The other explanation is that the formation of simple nitrogenous compounds takes place so rapidly during the height of the growth period that protein synthesis lags somewhat behind. In other words, material for protein synthesis is produced much faster than it can be utilized. The second explanation seems to be the more plausible one. Certainly the high nitrogen content of the susceptible plants would seem to have something to do with their infection by the mildew. Otherwise, they would not be so much more susceptible at one time than at another.

Calcium, to which the high ash content of susceptible *Oenothera* is largely due, is present in the living plant in the form of raphides of calcium oxalate. Its presence may indirectly benefit the mildew by neutralizing some of the acids in the cell sap. However, complicated questions of plant physiology are here concerned, and the suggestion would hardly be made if it were not for the definite correlation of high ash content with low acidity. Bartlett informs me that the most heavily mildewed *Oenothera* plants he has ever seen were on shingle of a river bank at the base of limestone cliffs. The fact that the total ash is considerably higher in the susceptible plants than in the resistant plants indicates that possibly the rate of absorption of the inorganic elements differs considerably. Since the inorganic salts absorbed from the soil together with the carbon dioxide taken in from the atmosphere constitute the raw materials for the synthesis of food in the plant, it seems very suggestive that the causes for the differences in the amount of elaborated constituents can be traced back to differences in salt absorption.

A chemical basis for true immunity does not necessarily imply the presence of some toxic substances in the resistant plants and the complete absence of such substances in the susceptible plants; conversely, it does not imply the presence of some chemotactic substance in the susceptible plants that does not exist in the resistant ones. Differences of the concentration of these substances in the sap, as well as their localization in the tissues of the plant, are two of the main factors to be considered. A resistant plant and a susceptible one may both contain the same toxic substances or chemotactic substances; but, if the amount of such substances present in one or the other is small, or if they are differently located, then they may exercise no harmful or beneficial influence on the fungus. The effect of the concentration of the substances in the cell sap is well shown in the experimental results obtained with the susceptible and the resistant strains of *Oenothera,* while the effect due to difference of location of the substances in the tissues of the plant is purely an expression of opinion arising from the fact that not all other investigators have been able to establish definite correlations between composition (especially with regard to tannin) and resistance to infection.

SUMMARY AND CONCLUSIONS

1. Chemical analyses of several resistant and susceptible hybrids and elementary species of *Oenothera* were made in order to discover whether or not there were definite correlations between chemical composition and reaction to mildew. The chemical analyses were also extended to other plants which were

found to have strains resistant and susceptible to other forms of powdery mildew.

2. The resistant strains are characterized by being higher in tannin and water-soluble acid. In the majority of cases, they are also higher in crude fiber than the susceptible ones.

3. The susceptible strains are comparatively high in total nitrogen and total ash.

4. The forms of nitrogen that are high in the susceptible strains during infection are the amino acids and nitrogenous compounds of nonbasic character. When the plants are approaching senility, the leaves of the susceptible plants are extremely rich in protein nitrogen.

5. The ash of the susceptible plants is exceedingly high in calcium and sulphur, as compared with that of the resistant plants.

6. All the strains examined, comprising wild elementary species, reciprocal hybrids, and mutations, show the same correlation of chemical composition with disease resistance.

7. The differences in chemical composition are found in both resistant and susceptible strains, before infection and after, and during the period when the leaves of the plants show chlorophyll degradation, indicating that the characteristic features of the resistant and the susceptible strains are constitutional.

8. The chemical analyses made of the susceptible and the resistant plants of *Syringa vulgaris, Desmodium canadensis, Helianthus giganteus,* and *Solidago canadensis* confirm the findings in regard to *Oenothera.* An exception was found in the total ash and water-soluble acid contents of *Helianthus giganteus,* but the plants were wild and may not have been genetically as close as appearance indicated.

9. Resistance in plants is doubtless due to a complex of interacting factors. Factors that increase tannin and acid and that decrease water-soluble nitrogenous compounds tend to build up immunity.

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APPENDIX

RECORD OF THE PARENTAGE OF ALL STRAINS OF OENOTHERA USED IN THE EXPERIMENTS

[C always indicates the type strain of *Oenothera pratincola* Bartlett known as "Lexington C." Similarly D indicates *Oe. numismatica* Bartlett, known as "Lexington D." See Bartlett (4) 1915.]

0847[1] = C–52–6–25–1–41 *typica*........................
×
C–22–15
× 1–25–34 *simulans*............ 7–19
C–22–10
= resistant *Oe. pratincola* (a segregate from species hybrid).
×
CD–9–49–6 *typica*......
× 2–33–1......................
CD–9–9–46 *simulans*
(= reciprocal of 0822.)

1827 = 0847–4.
2960 = 0847–4–10.

0822 = CD–9–49–6 *typica*.......
× 2–33–1......................
CD–9–9–46 *simulans*..
= mildewed *Oe. pratincola* (a segregate from species hybrid).
×
C–52–6–25–1–41 *typica*........................
×
C–22–15
× 1–25–34 *simulans*............. 7–19
C–22–10
(= reciprocal of 0847.)

1824 = 0822–26.
2959 = 0822–26–34.

0846 = C–52–6–25–1–41 *typica*........................
×
C–22–15
× 1–25–34 *simulans*............. 7–21
C–22–10
= *Oe. pratincola* hyb. *immunis*.
×
CD–9–49–6 *typica*......
× 2–33–22....................
CD–9–9–46 *simulans*..
(= reciprocal of 0823.)

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[1] These numbers represent "culture number" of the strain; that is, the number under which a progeny was grown in the garden.

1826 = 0846–2.
2956 = 0846–2–31.
0823 = CD–9–49–6 *typica*.......
× 2–33–22....................
CD–9–9–46 *simulans*..
×
C–52–6–25–1–41 *typica*........................
× 7–21
C–22–15
× 1–25–34 *simulans*..............
C–22–10
(= reciprocal of 0846.)
= mildewed *Oe. pratincola* (a segregate from species hybrid).

1825 = 0823–5.
2954 = 0823–5–61.
0830 = Cartersville 13d–1–22–24–5–6..........................
×
CD–9–49–6 *pratincola typica*..
× 2–33–23.....
CD–9–9–46 *simulans*.................
(= reciprocal of 0830.)
= *Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*

1804 = 0830–7.
0820 = CD–9–49–6 *pratincola typica*..
× 2–33–23.....
CD–9–9–46 *simulans*..................
×
Cartersville 13d–1–22–24–5–6..............................
(= reciprocal of 0830.)
= *Oe. pratincola* hyb. *immunis* × *Oe. mississippiensis.*

1805 = 0820–36.
0829 = Cartersville 13d–1–22–24–5–7............................
×
CD–9–49–6 *pratincola typica*..
× 2–33–23.....
CD–9–9–46 *simulans*..................
(Similar to 0830.)
= *Oe. mississippiensis* × *Oe. pratincola* hyb. *immunis.*

1818 = *cinerescens* (2) 9–3_{16}–5–20–1..............................
×
CD–9–49–6 *pratincola typica*.. 60
× 2–33–17.....
CD–9–9–46 *simulans*..................
(= F_1 of reciprocal cross of parents of 1819.)
= *Oe. cinerescens* × *Oe. pratincola* hyb. *immunis.* (Matroclinic in morphology.)

2966 = 1818–75.
1819 = CD–9–49–6 *pratincola typica*..
× 2–33–17.....
CD–9–9–46 *simulans*..................
× 4
cinerescens (2) 9–3_{16}–5–20–1..............................
(= F_1 of reciprocal cross of parents of 1818.)
= *Oe. pratincola* mut. *immunis* × *Oe. cinerescens.* (Matroclinic in morphology.)

2963 = 1819–18.
0838 = "*biennis Chicago*" 2–20–3–1..............................
×
CD–9–49–6 *pratincola typica*..
×
CD–9–9–46 *simulans*.................. 2–33–19.....
= *Oe.* "*biennis Chicago*" × *Oe. pratincola* hyb. *immunis.*
(= reciprocal of 0821.)
0821 = CD–9–49–6 *pratincola typica*..
×
CD–9–9–46 *simulans*.................. 2–33–19.....
×
"*biennis Chicago*" 2–20–3–1..............................
= *Oe. pratincola* **hyb.** *immunis* × *Oe.* "*biennis Chicago.*"
(= reciprocal of 0838.)
0814 = *cinerescens* (2)–9–3_{16}–5–20–3..............................
×
Cartersville 13d–1–22–24–5–5..............................
= *Oe. cinerescens* × *Oe. mississippiensis.*
(= reciprocal of 0827.)
1802 = 0814–64.. = *Oe. cinerescens* × *Oe. mississippiensis* (metaclinic).
2958 = 0814–64–27.
0827 = Cartersville 13d–1–22–24–5–5..............................
×
cinerescens (2)–9–3_{16}–5–20–3..............................
= *Oe. mississippiensis* × *Oe. cinerescens.*
(= reciprocal of 0814.)
1800 = 0827–12.
2957 = 0827–12–12.
0299 = C–52–6–31–73–19–6 *typica*..............................
×
C–52–6–31–72–3 *typica*..........................
×
reynoldsii typica debilis 56–21.......... 9.......
2
= *Oe. pratincola* × *Oe. reynoldsii* (*Oe. pratincola* hyb. *amycosa.*)
(Similar in genetic constitution to reciprocal of 0177.)
0177 = *reynoldsii typica debilis* 56–21..............................
×
C–52–6–31–73–3.. 6–4
= *Oe. reynoldsii* × *Oe. pratincola.*
0842 = "*biennis Chicago*" 2–20–3–2..............................
×
C–52–6–25–1–41 *typica*..........................
×
C–22–50
×
C–22–10 1–25–34 *simulans*.............. 7–22
= *Oe.* "*biennis Chicago*" × *Oe. pratincola* hyb. *rubricalyx.*
(= reciprocal of 0849.)
1816 = 0842–4.
2962 = 0842–4–10.

0849 = C-52-6-25-1-41 *typica*
×
C-22-15 × C-22-10 1-25-34 *simulans* 7-22
×
"*biennis Chicago*" 2-2-3-2 = *Oe. pratincola* hyb. *rubricalyx* × *Oe.* "*biennis Chicago.*"
(= reciprocal of 0842.)

1817 = 0849-8.

2961 = 0849-8-12.

0831 = Cartersville 13^{d}-1-22-24-5-3
×
"*biennis Chicago*" 2-20-3-1 = *Oe. mississippiensis* × *Oe.* "*biennis Chicago.*"
(= reciprocal of 0839.)

1806 = 0831-10.

0841 = "*biennis Chicago*" 2-20-3-1
×
Cartersville 13^{d}-1-22-24-5-3 = *Oe.* "*biennis Chicago*" × *Oe. mississippiensis.*
(= reciprocal of 0831.)

0839 = "*biennis Chicago*" 2-2-3-2
×
Cartersville 13^{d}-1-22-24-5-8 = *Oe.* "*biennis Chicago*" × *Oe. mississippiensis.*
(= similar to 0841.)

1807 = 0839-2.

0833 = Cartersville 13^{d} 1-22-24-5-6
×
CD-52-6-25-1-41 *typica*
×
C-22-15 × C-22-10 1-25-34 *simulans* 7-22 = *Oe. mississippiensis* × *Oe. pratincola* hyb. *rubricalyx.*
(= reciprocal of 0848.)

1810 = 0833-6.

0848 = C-52-6-25-1-41 *typica*
×
C-22-15 × C-22-10 1-25-32 *simulans* 7-22
×
Cartersville 13^{d}-1-22-24-5-6 = *Oe. pratincola* hyb. *rubricalyx* × *Oe. mississippiensis.*
(= reciprocal of 0833.)

1811 = 0848-60.

1346 = E-5-208-1-182 *nitidissima*
×
E-43-74-21 *typica* 7-1-10 = *Oe. pratincola* mut. *nitidissima.* (Resistant.)

1348 = same as 1346.

1347 = E-5-208-1-182 *nitidissima*
×
E-43-74-21 *typica* 7-1-11 = *Oe. pratincola* mut. *nitidissima.* (Mildewed.)

1349 = same as 1347.

199 = D–1–11–24–28–45–34–9–25 .... = *Oe. numismatica.*

1191 = CD–9–9–42–31–572–1–11 .... = *Oe. pratincola* mut. *simulans.*

1192 = C–22–15
× 1–24–2–29–9–4 .... = *Oe. pratincola* mut. *simulans rubricalyx.*
C–22–10

1829 = CD–9–49–6 *typica* ....
× 2–33–1–8 .... = *Oe. pratincola* hyb. *immunis.*
CD–9–9–46 *simulans* ....

2953 = 1829–36.

1231 = *reynoldsii typica debilis* 56–21
× 6–7–11 .... = *Oe. reynoldsii* × *Oe. pratincola.*
C–52–6–31–73–3 *typica* ....

167 = C–52–6–25–1–43–2–22–4 *typica* .... = *Oe. pratincola* (susceptible.)

1828 = Cartersville 13^{d}–1–22–24–5–9–7 .... = *Oe. mississippiensis.*

1195 = C–52–6–25–1–41 *typica* ....
×
C–22–15
× 1–25–34 *simulans rubricalyx* ..... 1–7–3 = *Oe. pratincola* hyb. *rubricalyx.*
C–22–10

1234 = 89–85–40–46–44–22–11 *typica reynoldsii* ..... = *Oe. reynoldsii.*

2950 = "*biennis Chicago*" 2–20–3–1–1–2 .... = *Oe.* "*biennis Chicago.*"

2952 = C–52–6–25–1–4 *typica* ....
×
C–22–15
× 1–25–34 *simulans* .. 7–19–21–27 = *Oe. pratincola* hyb. *rubricalyx.*
C–22–10

CHEMOTHERAPEUTIC EXPERIMENTS WITH CHAULMOOGRA AND ALLIED PREPARATIONS

III. THE DISINFECTING POWER OF THE VAPORS OF VEGETABLE OILS TOWARD ACID-FAST BACTERIA

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The results of previous experiments demonstrated the growth-inhibiting effect upon acid-fast bacteria of certain vegetable oils. It seemed to be of interest to arrange experiments so as to ascertain to what extent, if at all, these oils (produced, as they are, by plants in nature and some of them widely used in everyday life) contribute to the natural disinfection of objects exposed to the atmosphere, which is filled with their volatile constituents or secondary products.

Only those oils are included, therefore, in these tests which showed inhibitory activity on previous occasions. Since in these experiments direct contact was prevented between the oils tested and the inoculated bacteria, only those constituents and secondary products came into action which evaporate in sufficient amount at incubation temperature (37° C.); that is to say, gases evolved and constituents of low boiling point.

A great many of the oils previously tested had a considerable inhibitory effect upon *Bacillus tuberculosis* when brought into direct contact with the freshly inoculated culture. It was expected that, in some cases at least, it might be possible to reach a decision as to whether in a case of a given oil the inhibition of growth is due to the direct action of the stable constituents or to the volatile constituents and secondary products given off during the process of drying.

The following technic was employed in these experiments: Glycerine-meat-infusion-agar slants were planted with a well-growing strain of *B. tuberculosis*, human type, a small loopful of growth being transferred and distributed well over the surface of the slant. About 0.1 cubic centimeter of the substance to be tested was placed on the inner end of the cotton plug. The cotton plug was immediately replaced in the culture tube and sealed with paraffine. From the time the wetted cotton plug was replaced the culture tubes were handled and incubated in an inverted position (plug down). Readings were made two weeks and, again, four weeks after incubation. For comparison freshly inoculated cultures of *Staphylococcus, Vibrio choleræ, Bacillus dysenteriæ,* and *B. coli* were similarly treated.

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[1] Member, Philippine Leprosy Research Board.

TABLE 1.

Name of oil.	*Bacillus tuberculosis.*	*Staphylococcus.*	*Vibrio choleræ.*	*Bacillus dysenteriæ.*	*Bacillus coli.*
Bergamot	=	+	+ Inh	+	+
Caryophyllum	=	+	+	+	+
Cashew	+ +	+	+	+	+
Cedar	+Inh +Inh	+	+	+	+
Ceara rubber	+ +	+	+	+	+
Cinnamon	=	+ Inh	+ Inh	+ Inh	+ Inh
Citrus microcarpus	=	+	—	+	+
Coconut	+ +	+	+	+	+
Copaiba	+ +	+	+	+	+
Dacrydium	=	+	—	+	+
Eucalyptol	=	+	—	+	+
Palomaria	+Inh +Inh	+	+	+	+
Pinus sylvestris	=	—	+	+	+
Pittosporum	=	—	+	+	+
Turpentine	=	+ Inh	+ Inh	+	+
Vetiver	+Inh +Inh	+	+	+	+
Chaulmoogra (Japan)	+ +	+	+	+	+
Hydnocarpus alcalæ	+ +	+	+	+	+
Hydnocarpus subfalcata	+ +	+	+	+	+
Hydnocarpus venenata	+ +Inh	+	+	+	+
Hydnocarpus wightiana	+ +	+	+	+	+
Gynocardia odorata	+ +	+	+	+	+

The following abbreviations are used in Table 1:

+ = Growth same as untreated control.
$\begin{matrix}+\\+\end{matrix}$ = Growth same as untreated control in two and four weeks.
$\begin{matrix}-\\-\end{matrix}$ = No growth in two and four weeks.
− = No growth in forty-eight hours.
+ Inh = Scanty growth.
$\begin{matrix}+\text{ Inh}\\+\text{ Inh}\end{matrix}$ = Growth in two and four weeks scantier than controls.

This experiment produced evidence that vapors of oils containing acids of the chaulmoogric series show no disinfecting effect whatsoever. On the other hand, a great many essential oils, such as bergamot, *Caryophyllum,* cinnamon, *Citrus microcarpus, Dacrydium,* eucalyptol, *Pinus sylvestris, Pittosporum,* and turpentine evolved a sufficient amount of volatile and active constituents to inhibit completely the growth on agar of one loopful of viable tubercle bacilli in the proportion of 0.1 cubic centimeter to 15 cubic centimeters of closed air space at 37° C.

No evidence was adduced in these experiments to show that fixed vegetable oils evolve at the low temperature of 37° C. a sufficient amount of secondary volatile products to cause inhibition of growth of acid-fast bacteria in vitro.

CONCLUSIONS

The vapors of chaulmoogra and *Hydnocarpus* oils show no disinfecting effect upon acid-fast bacteria.

The volatile constituents of certain essential oils show high disinfecting activity with a strong indication of selectivity toward acid-fast bacteria.

MONILIA PSILOSIS ASHFORD IN SEVERE ANÆMIA ASSOCIATED WITH THE SPRUE SYNDROME

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ONE PLATE

The persevering work of Ashford(1–8) in Porto Rico during the past few years, establishing "sprue" on a sound laboratory basis as an infectious disease due to the causative microörganism *Monilia psilosis*, has not yet been fully accepted. The condition has been so long a bone of contention, particularly among clinical investigators, that it is not surprising perhaps that this should be so. This unsettled state of affairs is, therefore, my justification for publishing these notes on the occurrence of a *Monilia*, which fulfills the cultural and serological requirements and presents the morphological characteristics of Ashford's *Monilia*, in certain fatal cases of anæmia associated more or less definitely with the syndrome recognized clinically as sprue.

My attention was first called by Major J. Earle Ash, of the Sternberg General Hospital staff (United States Army hospital), in Manila, to a small group of cases presenting an anæmia of an extraordinary degree, resembling pernicious anæmia in its severity and the rapidity of its course, but showing very few of the morphological changes of the blood commonly found in that condition (Plate 1, fig. 1).

The red cell count in the typical advanced case is under one million, and the leucocyte count is correspondingly diminished to about three thousand or less per cubic millimeter. The differential count shows a marked relative lymphocytosis, often as high as 85 per cent, while the polymorphonuclear neutrophiles are proportionately decreased. A few atypical large mononuclear cells are occasionally seen and, rarely, a basophilic or eosinophilic polymorphonuclear can be found. The platelets are absolutely decreased to from 100,000 to 150,000, as a general rule. On careful examination of the red cells, with the usual triacid strains (Wright's, Jenner's, Giemsa's) it is noted that, while there is a slight tendency to microcytosis, there is seldom an appreciable poikilocytosis. Furthermore, the cells, while tremendously diminished in actual numbers, when examined under the microscope appear essentially normal. The hæmoglobin percentage is, of course, low, usually from 30 to 40, thus giving a high color index.

Another noticeable feature of the blood film is the absence of any evidence of marrow activity; there are usually no nucleated red cells, or at the most a very occasional one; there is no stippling or polychromatophilia; and the reticulated red cell count ordinarily is within or under normal limits. The fragility of the red cells as tested in varying dilutions of hypotonic salt solution shows a very slight increase in resistance, moving never more than two tubes. In short, the blood findings are those we familiarly associate with the so-called idiopathic (sui generis) aplastic anæmia, the literature of which I collected in 1918.(17)

Another striking feature of the disease is that, at least in the group of cases seen by Ash, it always occurs in Europeans or Americans who have lived in the Tropics a number of years, and that it is always associated with the syndrome commonly recognized as sprue; namely, a chronic intestinal disturbance characterized typically by enormous frothy, pale stools, nausea, gaseous eructations, abdominal distress, a sore tongue somewhat like that of pernicious anæmia, and finally emaciation and death.

With this picture in mind it occurred to me that here was an opportunity perhaps to secure evidence concerning the production of this condition. The term "sprue," as commonly used in the Philippine Islands and elsewhere in the Tropics, is unquestionably a much-abused one. Sprue and dengue are household words to every white inhabitant of the Tropics. Dengue is apt to be the casual diagnosis given to most acute infections having a duration of not more than a week or ten days, in which some definite causative agent is not found or recognized. Sprue, similarly, is the name applied to many of those chronic or intermittent intestinal disturbances in which amœbæ or dysentery bacilli cannot be found. The importance, therefore, of being able to establish sprue on the basis of a true infectious disease, capable of recognition by laboratory methods, either cultural or serological, or both, is obvious. Ashford (1–8) has done the pioneer work in that field in Porto

Rico; but, as he himself comments, it should be corroborated in other parts of the world. That his work has not as yet gained general acceptance may be indicated by a recent paper of Bovaird,(10) of New York.

This paper deals with several cases presenting the picture of severe anæmia associated with the chronic intestinal disturbances of sprue. The cases in every way coincide with those seen earlier with Ash before this work was begun, and lead me to believe that they form a perfectly definite clinical entity. All the cases, with a single exception, occurred in Europeans or Americans who had lived in the Tropics several years. The exception was the case of a Filipino, 30 years of age; but, in spite of slight differences in the clinical picture, I feel that it probably belongs in this group.

The incentive to follow up this problem came from the incidental finding of a *Monilia* from the tongue scrapings and stool of one of these severe cases of anæmia. On isolating this organism it was interesting to note that it conformed in morphological and cultural characteristics to *Monilia psilosis* as described by Ashford. This in itself was of great significance as, to my knowledge, this particular species had not been reported from the Philippines previously. Accordingly, as other cases appeared, efforts were made to isolate the same *Monilia,* and thus far they have been strikingly successful. Interestingly enough, in a large series of controls (including Caucasians, Chinese, and Malays), no definitely comparable *Monilia* has been found; and in those cases where some other *Monilia* was present, the serological reaction or cultural characteristics excluded its specific nature.

It has long been conceded, I believe, by most investigators of sprue, that yeasts or fungi of one sort or another are usually found in connection with these cases. The chief discussion has always been whether the yeast was causative or merely coincidental.

The cases on which this work is based are outlined briefly below, only the essential points in the history and laboratory findings being given.

CASE M.S., I

A Spanish woman, aged 52, born in Guam, and who had lived in the Philippines for the past twenty years except for one visit to Spain two years ago, had had intermittent attacks of diarrhœa for about five years. While in Spain her condition showed some improvement. Shortly after her return to Manila eight months ago, she developed a marked recurrence of her diarrhœal attacks. These increased in frequency and were accompanied by nausea, gaseous eructations, and abdominal distress. During the past three months she grew weak, lost over 30 kilograms in weight, and became very pale. Her tongue was so painful at times that she refused to eat because of the discomfort of mastication and deglutition. She had been treated by several physicians without any marked improvement, and finally consented to enter the hospital only as a last resort. During her stay of about a month her condition grew progressively worse, and in spite of transfusion and very careful treatment she gradually lost strength and died. No autopsy could be obtained.

The laboratory examinations in brief follow:

TABLE 1.—*Blood examination of M.S., I.*

Date.	Red cells per cubic millimeter.	Leucocytes per cubic millimeter.	Tallquist hæmoglobin.	Differential count.			
				Polymorphonuclears.	Lymphocytes.	All others.	Nucleated red cells.
			Per cent.				
November 15	1,264,000	3,200	40	33	61	6	0
November 20	1,056,000	2,800	30	26	70	4	0
November 25	976,000	2,300	30	24	69	7	2
November 30	784,000	2,400	20	16	81	3	0
December 5	[a] 2,832,000	4,900	50	44	47	9	3
December 10	2,112,000	3,400	50	89	54	7	1
December 15	1,656,000	2,800	40	38	54	8	1

[a] Post transfusion.

Blood films.—All smears showed a typical aplastic picture with slight microcytosis, no polychromatophilia, stippling, or reticulation, and very little poikilocytosis. The leucocytes were small, mature in type, with a progressive preponderance of lymphocytes, relatively. Practically no nucleated red cells were seen. The platelets were definitely diminished, ranging from 100,000 to 125,000. The fragility, as tried on two occasions, read from 0.40 to 0.22.

Cultures.—Tongue scrapings on repeated examinations yielded a characteristic mycelium which showed good growth on Sabouraud's medium after forty-eight to seventy-two hours and which conformed to the requirements of Ashford's *Monilia psilosis*, producing acid in dextrose, levulose, galactose, and saccharose, causing no change in litmus milk, or lactose, and having inverted pine-tree appearance in gelatine media. Similarly, cultures from the large, soft, frothy, greenish gray stools gave an identical *Monilia* on several occasions.

Complement fixation.—Positive with an aqueous extract of *Monilia psilosis* as antigen.

CASE M.S., II

Mrs. A., an American, has lived constantly in Manila for the past twelve years. She has not felt really well since an attack of amœbic dysentery three years ago. During the past four months she has had "bilious" attacks with nausea, abdominal pain, a good deal of gas, and alternating periods of diarrhœa and constipation. Her mouth and tongue have been painful for the past six weeks. She has completely lost her appetite, is pale in appearance, and has lost some weight.

Blood examination.—The blood showed a hæmoglobin of 45 per cent, a red cell count of 2,864,000, and the typical hypoplastic appearance of the bone marrow as evidenced by the stained film. The leucocytes numbered 4,400, with 38 per cent polynuclears, 59 per cent lymphocytes, and 3 per cent eosinophiles. The platelets numbered 160,000. The fragility was normal, 0.42 to 0.28.

Cultures.—From both mouth and stool, positive for *Monilia psilosis*. Stools were pale, soft, and somewhat frothy.

Complement fixation.—Positive.

Patient returned to the United States following transfusion, and the end result is not known at present writing.

CASE M.S., III

Philippine General Hospital No. 105272, D.M., aged 30, Filipino. The history differs from the others in an insidious onset of four years' duration, the chief symptoms of which were progressive weakness and pallor accompanied by intermittent œdema of the legs, but no loss of weight. His appetite has not been impaired. There has been only a vague history of gastrointestinal disturbance. From the history alone a diagnosis of hookworm disease might be suggested tentatively; but, in view of the laboratory findings (a positive stool for *Monilia*, the positive complement fixation, the absence of parasites or ova in the stools, and the typical blood picture of this group of cases), it seems more probable that it should be classified as an abortive form of the disease. This patient developed a lobar pneumonia two days after admission to the hospital and died. The autopsy findings are consistent with the diagnosis.

Blood examination.—On admission the blood showed a red cell count of only 630,000, a white cell count of 3,200, and a hæmoglobin of approximately 30 per cent. The differential count gave 52 per cent polymorphonuclears, 47 per cent lymphocytes, and 1 per cent eosinophiles. The blood film presented the typical picture of nearly normal appearing red cells, diminished in number, but showing very slight changes in size or shape, no polychromatophilia, stippling, or reticulation, and no normoblasts.

Cultures.—Stools were positive for *Monilia psilosis* and *M. albicans.*

Complement fixation.—Positive.

CASE M.S., IV

Mrs. F., an American, 45 years of age, who had suffered from "chronic dysentery" for several years, finally sought medical advice for marked asthenia, loss of weight, and general poor health. A blood smear was taken and a red cell count made. The red cells numbered between 800,000 and 900,000. The smear I had an opportunity to examine, through the courtesy of her attending physician. It showed the same lack of anisocytosis and poikilocytosis previously commented on, and gave no evidence of marrow activity, such as stippling, polychromatophilia, reticulation, or the presence of nucleated red cells. The differential count showed a preponderance of lymphocytes, 71 per cent. Cultures or serum were unfortunately not obtained from this case. Transfusion was recommended and refused, and the patient died on her way back to the United States.

CASE M.S., V

Mrs. B., a Spanish-American mestiza, 48 years of age, a resident of Manila for over twenty years, entered the hospital complaining of weakness, loss of weight, chronic diarrhœa, and a sore mouth. Her history dated back about two years, with an acute exacerbation of only about three months' duration. Examination of the blood gave a red cell count of 2,164,000 per cubic millimeter, a white cell count of 3,800 per cubic millimeter, a hæmoglobin of 40 per cent by Tallquist, a differential white count with 32 per cent polymorphonuclear leucocytes, 61 per cent lymphocytes, and 7 per cent miscellaneous leucocytes, a platelet count of 200,000, a fragility test reading from 0.40 to 0.24 per cent sodium chloride, and a stained film presenting the previously noted peculiarities.

Cultures.—From stool, positive for *Monilia psilosis.* Cultures from tongue, also positive.

Complement fixation.—Positive.

CASE M.S., VI

Mr. H., an American ex-soldier, 35 years of age, who has lived in the Philippines for eight years, came to the hospital dispensary complaining of weakness and chronic diarrhœa. He has a history of previous amœbic dysentery and malaria, three and two years ago, respectively. A routine examination of his blood and stool revealed a moderate anæmia and the presence of several imperfect fungi, among them *Monilia psilosis.* His red cell count was 2,864,000 per cubic millimeter, his leucocytes numbered 4,900 per cubic millimeter, and his platelets were approximately 300,000 per cubic millimeter. His hæmoglobin was around 55 per cent by Tallquist. The differential count in this case was nearly normal, with 58 per cent polymorphonuclear leucocytes, 38 per cent lymphocytes, and 4 per cent eosinophiles. The blood smear showed the same general absence of bone marrow activity. In other words, the anæmia was more of an aplastic than a secondary type, morphologically. The serological reaction with a *Monilia* antigen was positive, and the organism was isolated from both the mouth and the stools. The case was a relatively mild one, was treated by transfusion, and three months later he appeared much improved, with a red cell count of 4,500,000 and no symptoms.

CASE M.S., VII

Mr. E., an American, 40 years of age, for about two years has complained of vague or mild intermittent gastrointestinal disturbances. Recently he has felt worse, tires easily, has lost interest in his work, is weak, and is losing weight. He had not particularly noticed any pallor, and his tongue and mouth have not been painful.

Blood examination.—The blood gave a red cell count of 2,120,000 per cubic millimeter, a white cell count of 5,800 per cubic millimeter, and a hæmoglobin percentage of 40. The platelets were not counted, but from smear preparation appear decreased in numbers. The differential count is: Polymorphonuclear neutrophiles, 51 per cent; lymphocytes, 42 per cent; eosinophiles, 4 per cent; and large mononuclears, 3 per cent.

The stained film shows findings similar to those noted previously; namely, a relatively normal appearance of what red cells are present, a slight tendency toward microcytosis, and absence of polychromatophilia, stippling, and nucleated red cells.

Cultures.—Positive from stool for both *Monilia psilosis* and *M. albicans;* from the tongue, *M. albicans* alone was obtained.

Complement fixation.—Doubtfully positive.

CASE M.S., VIII

Mr. O., an American, about 45 years of age, who has lived in the provinces of the Philippines for many years, and has suffered from typhoid, dysentery, malaria, dengue, and miscellaneous minor infections. He had felt as well as usual up to about two years ago when he had the typical history of sprue and was given dietetic treatment for about six months and felt much better. Was unable to keep this diet up because of the inaccessibility of the places where his work took him. Noticed increasing discomfort, with frequent attacks of nausea, "indigestion," and diarrhœa, developed sore tongue and throat, lost his appetite, and began to lose weight. He kept at work, however, until he was unable to rise from his bed because of weakness, and was taken to the hospital for treatment. He is a large man but, with the loss of over 30 kilograms, his skin hangs around his arms and legs in great folds. His color is a sallow, ashen gray. He vomits everything, including water, and is being kept alive by rectal feedings and intravenous injections.

Blood examination.—The red cell count is 584,000 per cubic millimeter; the white cells number 2,100; the hæmoglobin is inestimable, but by Tallquist about 15 per cent. The differential count shows a polynuclear neutrophilic percentage of only 11, while the lymphocytes show 83; there are 2 per cent eosinophilic leucocytes and 4 per cent large mononuclears. The stained film presents more marked changes than is usual, with perfectly definite although relatively slight variation in the size and morphology of the red cells. Achromia is more prominent likewise, and an occasional polychromatophilic cell is seen. No increase in reticulation or of stippling is noted, and no nucleated red cells are found. The platelets are reduced to under 100,000 per cubic millimeter. The fragility is decreased noticeably, beginning at 0.38 per cent sodium chloride and not being complete until 0.20 per cent.

Cultures.—A profuse growth of *Monilia psilosis* was secured from both mouth and stool specimens.

Complement fixation.—Positive.

In Table 2 we find a composite picture of the essential laboratory findings of these eight cases comprising the basic material for this paper. In referring to the blood pictures it is well to remember that the normal leucocyte picture among Filipinos is quite different from the one we are accustomed to in the United States. Guerrero and Sevilla(13) have reported that the normal polynuclear neutrophiles amount to 51.6 per cent; the lymphocytes, 34.5 per cent; and the eosinophiles, 11.2 per cent in a differential count. Whether this is true of the Tropics in general and therefore applicable to Europeans or Americans of long residence in the Philippines I am not prepared to state. It is unquestionably true that the high incidence of parasitic infection tends to raise the eosinophilia average. The sum of the reported leucocyte incidence of 51.6 per cent neutrophiles and 11.2 per cent eosinophiles is not very far from the average polynuclear count among Americans. This point I raise merely to exclude any possible criticism in regard to the standards of comparison. In general, it is distinctly my impression that the lymphocyte count averages from 10 to 20 per cent higher among Filipinos than among Americans, at the expense of the polynuclears. In this group of cases we see a distinct tendency toward a relative lymphocytosis, although an actual leucopenia is present. How much this is affected by the climatic or environmental factors, and how much by infection, are questions largely open to argument and personal opinion. Personally, I feel it is principally due to the infection, as I have not noted it generally among other cases.

CULTURAL STUDIES

The methods employed in obtaining the *Monilia* were essentially those of Ashford, his technic having been followed with only minor modifications.

Scrapings from the tongue mucosa and material from fæcal suspensions were plated on a modified Sabouraud's medium. This consists of a strongly acid (2.5 + per cent), 4 per cent maltose agar to which a small amount of glycerine had been added. The only advantage which the glycerinating of the medium seemed to accomplish was to secure a more rapid growth of the organisms, and thus much time was saved in the prelimi-

TABLE 2.—*Composite table of laboratory examinations.*

Case.	Red cells per cubic millimeter	White cells per cubic millimeter.	Platelets per cubic millimeter (in thousands).	Tallquist hæmoglobin.	Differential count.			Stained film.		
					Polymorphonuclears.	Lymphocytes.	All others.	Anisocytosis.	Poikilocytosis.	Polychromatophilia.
				Per cent.						
M.S., I[a]	784,000	2,400	100–125	20	16	81	3	+—	0	0
M.S., II	2,864,000	4,400	160	45	38	59	3	+—	0	0
M.S., III	630,000	3,200	----------	30	52	47	1	+	+—	0
M.S., IV	850,000	----------	----------	----------	26	71	3	+—	0	0
M.S., V[a]	2,164,000	3,800	200	40	32	61	7	+—	0	0
M.S., VI	2,864,000	4,900	300	55	58	38	4	0	0	0
M.S., VII	2,120,000	5,800	----------	40	51	42	7	+—	0	0
M.S., VIII[a]	584,000	2,100	80–100	15	11	83	6	----------	----------	----------
Average	1,607,500	3,800	----------	35	35.5	60.3	4.2	----------	----------	----------

Case.	Stained film.			Fragility hæmolysis.		Complement fixation with *Monilia* antigen.	Mouth cultures.		Stool cultures.	
	Stippling.	Reticulation.	Nucleated red cells per 100 white blood count.	Begins.	Ends.		*Monilia.*	Other yeasts, etc.	*Monilia.*	Other yeasts, etc.
M.S., I[a]	0	OK	0–1	0.40	0.20	++	+	+	+	+
M.S., II	0	OK	0	0.42	0.28	++	+	+	+	+
M.S., III	0	OK	1	(b)	(b)	(c)	(c)	(c)	(c)	(c)
M.S., IV	0	OK	0	(c)	(c)	(c)	(c)	(c)	(c)	(c)
M.S., V[a]	0	OK	0	0.40	0.24	++	+	+	+	+
M.S., VI	0	OK	0	0.44	0.28	+	+	—	+	—
M.S., VII	0	OK	1	(c)	(c)	+—	—	+	+	+
M.S., VIII[a]	0	OK	0	0.38	0.20	+	+	+	+	+
Average	----------	----------	P. 51.6	----------	----------	----------	----------	----------	----------	----------

[a] The breeding and clotting time in three cases showed no change.

[b] Unsatisfactory.

[c] Not examined.

nary isolation. All suspicious cultures were fished after twenty-four hours and planted in duplicate on Sabouraud's and the glycerinated Sabouraud's; the former to serve as the permanent culture, the latter to be used for transplants. After another twenty-four to forty-eight hours the organism was planted (*a*) in the various sugar fermentation media, (*b*) in litmus milk, and (*c*) in stab culture on Hiss' semisolid medium, a very satisfactory substitute for pure gelatine in the Tropics. Absolute identity of the *Monilia* species was checked by the appearance of massive cultures on Sabouraud's medium after two to three months, as the early cultures are not always readily differentiated even by their cultural reactions in milk and carbohydrates (Plate 1, fig. 2).

I present a table showing the reactions with twenty of the familiar laboratory sugars. As no additional information was obtained by the use of any but a few simple sugars, the complete examination was given up after the first three cases had been tested.

TABLE 3.—*Carbohydrate reactions with Monilia psilosis.*

Sugar used.	1	2	3
Adonite	—	—	—
Arabinose	—	—	—
Dextrose	+++	+++	+++
Dulcit	—	—	—
Galactose	++	+	+
Inosit	—	—	—
Inulin	—	—	—
Lactose	—	—	—
Levulose	+++	++	++
Mannit	—	—	—
Mannose	+	?+	?+
Maltose	+++	+++	+++
Melozitose	—	—	—
Quercit	—	—	—
Raffinose	—	—	—
Rhamnose	—	—	—
Saccharose	++	++	+
Sorbit	—	—	—
Trehalose	—	—	—
Xylose	+—	—	+—

In routine practice, therefore, dextrose, galactose, lactose, levulose, maltose, and saccharose were utilized for preliminary purposes of identification, the reaction with maltose, as Ashford has commented, being the most valuable. These, supplemented with litmus milk and Hiss' semisolid gelatine medium, serve admirably tentatively to classify the *Monlia* for, characteristically, *Monilia psilosis* shows no reaction in litmus milk and forms the so-called "inverted pine tree" in gelatine stab cultures.

It will be noted from Table 4 that there were usually obtained from the patients other organisms which were very often confusing. The most important of these is *Monilia albicans,* which apparently occurs with some regularity. Morphologically it is very difficult to differentiate these two *Monilia.* In massive cultures after two to three months *Monilia albicans* justifies its nomenclature by appearing a glistening snowy white, while *Monilia psilosis* has a distinctly dirty grayish yellow or brownish appearance and is much less refractive. In addition, the mycelial downgrowth in the medium is usually much more marked in the *M. psilosis* cultures.

Histologically, I have nothing to add to the original description as given by Ashford. The motile body in a pale vacuole is exceedingly characteristic in fresh preparations which, in combination with the large size of the organism and its round rather than oval outline, makes one reasonably certain of its identity.

Following in general the technic which Martinez(14,15) and Michel(16) developed in their work in Porto Rico on the specific fixation of the complement in sprue, a positive result was obtained in the six cases in which the test was performed, and negative results in over ten controls who complained of other chronic intestinal disturbances. By using a *Monilia albicans* antigen further controls were made. The technic and results are here reported.

Antigen.—The antigen was obtained by using three-week-old cultures of *Monilia psilosis* grown on Sabouraud's medium, washed off with sterile distilled water. This was emulsified by mechanical shaking for one hour and standardized by the usual blood counting chamber method. Phenol (0.5 per cent) was added as a preservative, after incubation for three days to secure autolysis. This was then heated to 58° C. for one hour and tested for sterility and hæmolytic or anticomplementary action. A similar antigen was prepared from *Monilia albicans* as control for the specificity of the *M. psilosis* cases. The standard used was 1 cubic centimeter.

Complement.—Three-tenths cubic centimeter normal pooled guinea pig serum (ten) was used.

Amboceptor.—One cubic centimeter of a 5 per cent suspension of washed monkey corpuscles was utilized.

The Wassermann test was performed with two series of tubes; one, containing 0.1 cubic centimeter of the suspected serum, the other 0.2 cubic centimeter of inactivated serum as control for the anticomplementary action. All set-ups were made in duplicate. Parallel series, using 0.7 cubic centimeter of *Monilia psilosis* and *M. albicans* antigen preparation, were run.

The suspected serum, antigen, complement, and salt solution to volume were heated for forty minutes, then the hæmolytic system was added, and the whole was incubated for one hour before the results were read. It will be noted that the *Monilia albicans* antigen gave faintly positive results in two of the sprue cases as well as in one of the nonsuspected cases. This may indicate a tendency toward group specificity, but apparently will offer no difficulty in the matter of differential diagnosis, especially if the serological reaction is performed quantitively with higher dilutions of the serum.

TABLE 4.—*Complete fixation with Monilia antigens.*

Patient.	Diagnosis.	*Monilia psilosis.*	*Monilia albicans.*
M.S., I	Sprue; anæmia	++	+—
M.S., II	do.	++	—
M.S., V	do.	++	+—
M.S., VI	do.	+	—
M.S., VII	do.	+—	—
M.S., VIII	do.	+	—
9432	Typhoid	—	—
9446	Tuberculosis	—	—
9454	Typhoid	—	—
9462	Bacillary dysentery	—	—
9467	Typhoid	—	—
9483	Amœbic dysentery	—	—
9490	do.	—	—
MH-17	Ankylostomiasis	—	+
MH-24	do.	—	—
9521	Epidemic encephalitis	—	—

The value of the complement-fixation reaction in the diagnosis of obscure intestinal disturbances simulating sprue, such as the chronic dysenteries, should be inestimable from the point of view of the therapeutist, as it offers apparently a truly specific means of diagnosing this relatively large group of cases.

DISCUSSION

One of the principal objects of this paper has been to present the extraordinary blood picture noted in this group of cases, and to discuss it in relation to our present knowledge of sprue.

If my enthusiasm and interest have carried me a bit outside the originally intended limits of my presentation, I plead for leniency, in as much as the other phases of the work were almost necessary to establish the cases in a recognized clinical place for the purpose of exposition in regard to the blood findings.

In reviewing the literature of sprue I find relatively few references to the blood. In Ashford's monograph in the new Oxford Medicine there is, I think, the strongest statement on record. I quote it in its essentials, as follows:

> The degree and character of the anemia in sprue as in many profound secondary anemias may approach the pernicious type, and * * * laboratory reports may arouse some doubt as to the nature of this anemia, whether it is secondary or essential. * * * The anemia of sprue becomes the dominant note, however, in some cases, * * * and may remain to oppose obstinately a cure.

Castellani and Chalmers (12) say:

> The blood coagulates slowly, and there is always some reduction of the red cells which may fall as low as 1,000,000 per cu. mm. The color index is *low*, and the structure of the cell is normal. The white cells also may be reduced to 2,800 per cu. mm. The ratio of white to red cells is about 1–400 in bad cases. A differential count shows an increase in the mononuclears and eosinophiles.

Brown (11) in 1906 makes a similar observation in reporting the leucocyte counts in twenty-two cases observed by him, in which the average figures showed percentages of 56 for neutrophiles, 20 for lymphocytes, 16 for large mononuclears, and 8 for eosinophiles. He feels that the red cell diminution is due to a toxic destruction of the circulating erythrocytes, similar to that in arsenic poisoning. His statements seem to be the basis of most subsequent comment.

Bahr (9) in 1914 stated that "though present as a general rule, a great degree of anæmia need not presage a fatal termination."

Aside from these few statements, only isolated reports of single cases are found, giving very little or incomplete information—a red count, a hæmoglobin value, a differential count, and so on.

It has been exceedingly unfortunate that practically no autopsy material has been obtained in the group of cases studied, for examination of the bone marrow and spleen might have assisted us in explaining the mechanism of the production of the anæmia. That the *Monilia psilosis* produces a toxin must be recognized, for experimentally we can cause the death of guinea pigs by the intraperitoneal or even subcutaneous injection of a few cubic centimeters of a saline suspension of the organism. The further experimental data will be reported in a subsequent paper, but it seems appropriate to mention at this time the fact that there seems to be definite evidence of the presence of a toxin in relation to this particular *Monilia,* in contrast to *Monilia albicans* which can be introduced into experimental animals in almost massive doses without the production of symptoms. On the other hand, the actual reproduction of the disease is extremely difficult to accomplish. This may depend in part on our choice of experimental animals, and in part on the element of time which is usually more or less disregarded, in direct contradiction of the facts as the disease appears in man.

The relatively slow development of sprue in man up to a certain point, followed by the very rapid emaciation and anæmia production, speaks strongly for a cumulative action on the part of the infecting agent. Physiologically, there is resistance up to a certain point; but, once that threshold is reached, the resistance is apparently done away with.

The bone marow in these cases gives every indication of complete paralysis or inhibition, as evidenced by the peripheral blood. We find none of the characteristic stimulating effects which a typical secondary anæmia seems to produce. Instead of activity on the part of the red-forming mechanism we find evidence of increased destruction going on and no compensatory hyperplasia of the marrow. The remaining red cells attempt to act defensively, appearing to shrink a trifle and in that way perhaps becoming slightly more resistant to hæmolysis. We should expect to find marked evidence of red-cell fragmentation in the spleen.

It is interesting to note how well the marrow responds to stimulation by transfusion of healthy red cells in the earlier stages, and how little it affects the picture in the later stages. This is of considerable importance from the therapeutic standpoint for, by improving the general condition of the patient through transfusion, the probable chances of vaccine therapy being of benefit are just so much more enhanced.

Thus far in neither guinea pigs nor rabbits have we been able to produce the blood picture seen in human cases; but there is sufficient circumstantial evidence, I think, to blame *Monilia psilosis* for the production of this severe anæmia, for it is constantly present in those cases, and thus far has not been recovered from other severe anæmias of a frankly secondary type.

The classification of this anæmia, therefore, offers certain difficulties. Strictly speaking, it is secondary to the *Monilia* infection and, therefore, secondary. From the point of view of histopathology, however, the morphological appearance of the cells and the diminution of platelets and of marrow activity exclude it from what is commonly meant by the secondary type of anæmia; and it does not present the morphological changes associated with the primary or essential anæmia that we call pernicious. It must by exclusion, then, belong to that other small group of cases spoken of loosely as aplastic. In this group we find certain hæmolytic agents which are responsible for a number of the cases; among them we can mention ricin, saponin, and even trinitrotoluol, while in a few no exogenous agent can be detected. The latter are the so-called idiopathic cases. Apparently, from purely circumstantial evidence, we can place *Monilia psilosis* in a position comparable to that of some of the aforementioned toxins, and the anæmia that accompanies it in the classification of aplastic anæmia. Whether experimental evidence will bear out this tentative grouping remains to be demonstrated, but it seems a logical disposition to make of these cases until further work settles the question.

SUMMARY AND CONCLUSIONS

Eight cases of severe anæmia associated with the sprue syndrome are presented, with their laboratory findings.

The isolation of *Monilia psilosis* Ashford, 1914, from these cases is described, which is the first time it has been reported from the Philippine Islands.

The specific nature of the complement fixation in sprue, using a watery extract of *Monilia psilosis* as antigen, is discussed.

The histopathology of the peripheral blood is described and on the basis of the blood picture a tentative classification of this anæmia as aplastic is suggested.

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ILLUSTRATION

PLATE 1

FIG. 1. Blood smear from case M.S., I, sprue, female, 52 years, Spanish. x Zeiss 4 millimeters objective and 12K ocular (15 x). Red blood count, 1,056,000. Relative normal appearance of red cells, only slight anisocytosis and poikilocytosis. Nucleated red cell represents only one seen in twelve examinations. High color index, only slight achromia. White blood count, 2,400. Relative lymphocytosis (approximately 65 per cent of differential count) and small size of lymphocytes. Diminished platelets, 102,000. The blood picture represents typical so-called "aplastic anæmia."

2. *Monilia psilosis*, eight-week-old culture.
3. *Monilia albicans*, twelve-week-old culture.

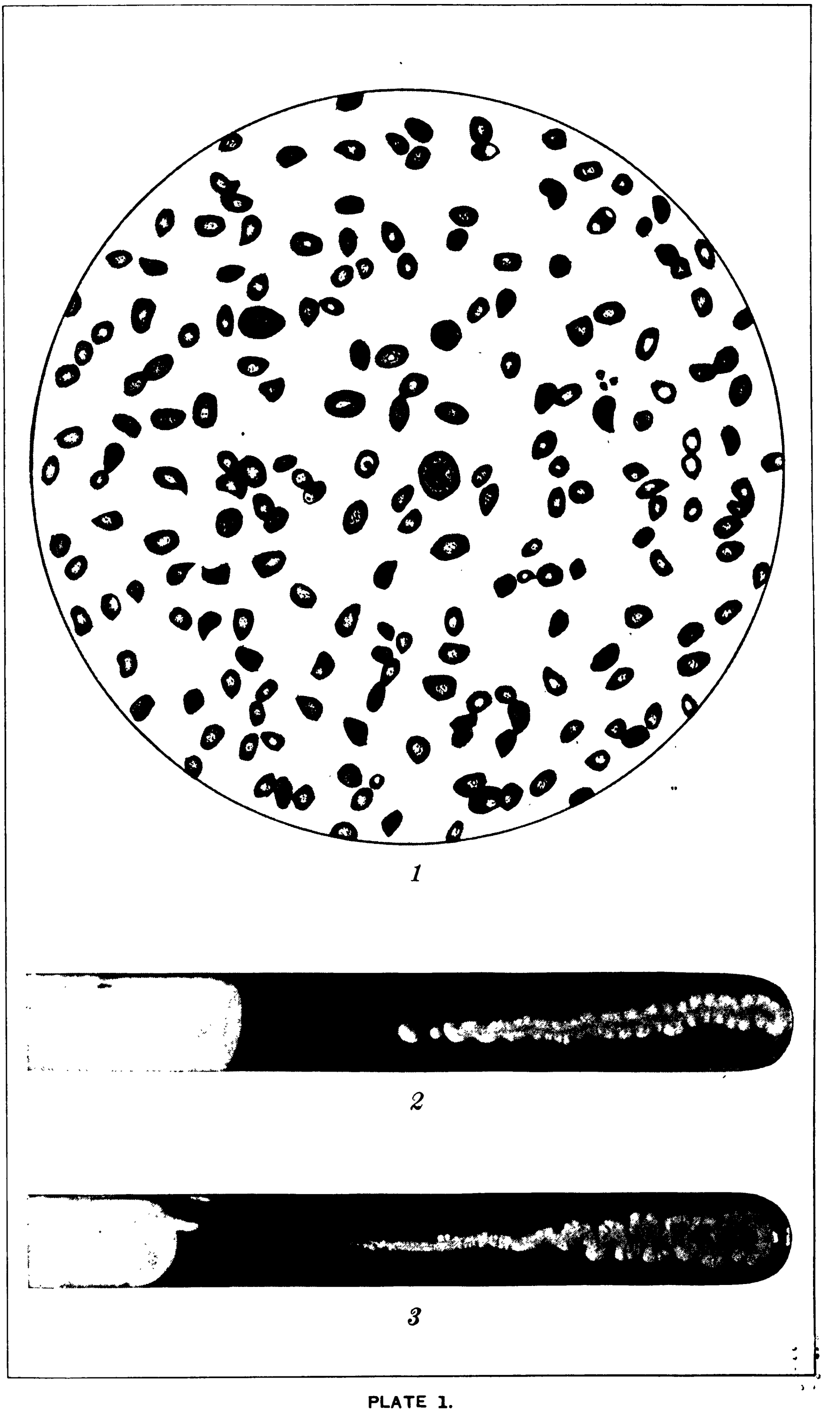

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PLATE 1.

HYDROIDS OF THE PHILIPPINE ISLANDS

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SIX PLATES

This report embodies the results of a study of the collection of Philippine hydroids made under the direction of Dr. Lawrence E. Griffin, of the University of the Philippines, during 1909, 1912, and 1913, and includes dredgings, scrapings, etc., from the interisland cables from depths of 8 to 177 fathoms.[1] The localities given by Doctor Griffin in his letter accompanying the transmission of the collection are Bantayan Island, Port Galera, Mindoro, Culion, Luzon, Palawan, and Taytay; there were also names on tags found in most of the bottles and jars in which the specimens were preserved. On most of the jars was also a number with the prefix C; for example, C2315, of the precise significance of which I am not advised. Perhaps it relates to a given haul of the dredge or it may be some arbitrary designation. In many cases a record of depth was included, but in none was there any record of latitude or longitude by which a given station could be later located.

Most of the material was preserved in 5 to 10 per cent formalin, but in a few cases alcohol had been used. Owing to the considerable interval before its reception at Syracuse and the unfortunate breakage of several jars in transit, some deterioration had occurred and the condition of perishable portions, such as hydranths and medusa buds, left much to be desired.

The collection comprises some fifty species which were identifiable; nearly half of them are probably new, and others had been little known. One of the latter, *Idia pristis* Lamouroux, has long been known, but until relatively modern times has been very inadequately described. In this collection it is one of the commonest, but until now I had not seen the species, and at first it seemed like a new find.

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[1] Earlier collections of hydroids from Philippine waters had apparently been rather small. The more important reports are: Busk, Voyage of H. M. S. Rattlesnake 1852; Kirchenpauer, Ueber die Hydroidenfamilie Plumularidæ, 1872; Bale, Hydroids, 1882, 1884; Allman, Hydroida dredged by H. M. S. Challenger, Part I (1883), Part II (1888); Marktanner-Turneretscher, Annal. k. k. Naturhist. Hofmuseums Wien (1889–1890); records of Japanese explorations; and still more recently the two admirable monographs by E. Stechow, Hydroidpolypen der Japanischen Ostküste, Part I (1909), Part II (1913). Besides these there are doubtless other records, but the number is relatively small.

The collections were made from one hundred thirty-five recorded stations, but there were doubtless others, as some containers were devoid of record, and from some that were broken in transit the record, if ever present, had been lost. Naturally, many of the records related to the same species, as implied in the fact that the number identified is less than half the total recorded.

Another matter of some interest is the intimate relationship of habitat revealed by this material; that is, many species were apparently always found in what seemed symbiotic relations, a smaller growing upon a larger. This has sometimes been designated as parasitism, but I am inclined to doubt the existence of that relationship among hydroids. In some cases the relations were doubtless merely incidental, as favorable hydroid conditions would be occupied by individuals of two or more species, and their growing together or upon each other is only what all students of hydroids very well know does occur. In the present material this habit was almost universal, an isolated specimen or colony being exceptional.

The study of the collection has been a matter of unusual interest, as it afforded an introduction to a tropical fauna having a large proportion of strange forms, among them the new genus and species *Zanclodea philippina.* This species affords another sidelight upon a problem of long standing and of perplexing difficulty; namely, that associated with Gegenbaur's Cladonemidæ and his genus *Zanclea,* based on the medusa stage alone. Even the medusa has been seldom certainly identified, and the hydroid is unknown to this day.

Genus **CORDYLOPHORA** Allman

Cordylophora dubia sp. nov.

Two bottles labeled as from stations C2311 and 2312 contained a few fragmentary specimens, poorly preserved, rendering specific identification difficult. Among those from station C2311, taken in June, 1913, in addition to the *Cordylophora,* were fragments of *Eudendrium, Obelia,* and a sertularian, indicating a marine source. Those from station 2312 were definitely labeled as taken from Mololas River, of the same date as those from the other. Whether or not there may have been some accidental mixing of the specimens it is impossible to say, though it is not impossible that the *Cordylophora* of the former, true to its variable habit, may have had its habitat in the salt water.

Trophosome.—This is distinctively of cordylophoran type, main stem branching alternately, perisarc smooth except at regions of branches, the latter having at their origin a few basal annulations; hydranths clavate rather than spindle-shaped with conical hypostome, the twelve tentacles filiform and tending to assume whorls, though scattered downward upon the hydranth body.

Gonosome.—The gonophores were badly preserved and impossible of critical determination as to structure. They usually appeared in clusters or groups on distal parts of branches, ovoid, each borne on its own pedicel; the gonangial capsules were similar to those of *Cordylophora lacustris,* yet in some respects distinctly different. The stems were slenderer, hydranths smaller, and gonangia clearly different.

While the material is such as to render uncertain many aspects of form and structure, and so leaves doubtful any definite pronouncement as to specific independence, it seems well for the purpose of record to list it as a doubtful new species, *Cordylophora dubia,* until better material may furnish final certainty.

Genus **BOUGAINVILLIA** Lesson

Bougainvillia philippensis sp. nov. Plate 1, fig. 1.

Specimens of this apparently new species of *Bougainvillia* were taken at stations 702 and 799, from depths of 40 and 54 fathoms, attached to small bivalve shells, the stolons creeping more or less in the grooves of the shell, and the surface seemingly covered with a mucous mass resembling somewhat that covering the hydrorhiza of *Hydractinia.*

Trophosome.—The hydrocaulus grows to a height of 10 to 15 millimeters, stems and branches covered with a smooth, firm perisarc, with occasional indefinite annulations at the origins of branches. Hydranths large, ovoid or broadly spindle form, with conical hypostome from the base of which arise about twenty to thirty filiform tentacles.

Gonosome.—Medusæ arise in compact clusters on the upper portions of stem and branches, and in my specimens in various stages of development, from mere buds to almost fully grown medusæ, some with tips of tentacles protruding from the bell, yet it was not possible to determine their structural details. In shape the body is rather pyriform as seen attached, and the ocelli could be readily distinguished, though the character of the manubrium could not be determined.

So far as I am aware, the only species with clustered medusæ is *Bougainvillia flavida,* described by Hartlaub,[2] though differing in most other features. Bonnevie has also described a species, *B. obscura,*[3] with some features in common, yet very distinct otherwise.

Genus **PERIGONIMUS** M. Sars

Trophosome.—Hydrocaulus simple or branched; hydrorhiza a filiform creeping or reticular network; hydranths fusiform, with conical hypostome; perisarc rather thin and usually with an outer encrustment of foreign particles extending to the base of the tentacles.

Gonosome.—Free medusæ, usually with high bell, and with two to four tentacles (usually two at liberation), arising from large basal bulbs, devoid of ocelli.

Perigonimus repens Hincks.

Perigonimus repens HINCKS, Brit. Hydr. Zooph. (1868) 90; CALKINS, Proc. Bost. Soc. Nat. Hist. (1899) 339.

Among material taken at stations 757, 790, and 879 were hydroids indistinguishable from this species, though owing to poor preservation it was difficult to confirm details of medusoid structures. The material was taken from depths of 10 to 100 fathoms, and mostly adhering to shells and stems of *Tubularia.*

Perigonimus scandens sp. nov. Plate 1, fig. 2.

The material was taken at stations 738, 778, 861, and 883, at the last from a depth of 110 fathoms. The species differs from any known to me, and from the following description will be recognized as new.

Trophosome.—Stems often fascicled in the older portions, and with a generally smooth and transparent perisarc, in striking contrast to that of most known species. Height, 15 to 20 millimeters; branching; hydranths low, vasiform, with domelike hypostome, tentacles rather short, twelve to sixteen; perisarc smooth, annulated at origin of branches.

Gonosome.—Medusæ borne on stems and branches, each on its own pedicel, which is annulated; as the medusæ approach maturity the two tentacles become conspicuous and often protrude from the bell; their basal bulbs are very large and devoid of ocelli.

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[2] Hydromedusen Helgolands (1897) 456–461, pl. 14, figs. 1–10.

[3] Neue norwegische Hydroiden (1898) 7, pl. 1, fig. 4.

The species seems to live upon other hydroids, creeping over them in parasitic fashion, and in this material always in such relation. The name proposed for the species is indicative of this climbing habit.

Hartlaub[4] has described a hydroid similar in its trophosome features to that here described, but he offers no specific account, as there were no gonophores present. His species was very minute, 6 millimeters in height and with but eight tentacles, with perisarc extending to their bases, a point of contrast with the above species.

Genus **CORYDENDRIUM** Van Beneden

Corydendrium minor Nutting.

Corydendrium minor NUTTING, Bull. U. S. Fish. Comm. Part 3 (1905) 941.

At stations 773, 836, 846, 853, and 855 were taken numerous colonies which seem to be identical with the species described by Nutting from Hawaii. I add such details as seem essential.

Trophosome.—Colonies mostly arising from stoloniferous filaments attached most frequently to other hydroids, though occasionally to other objects. I do not recognize any essential aspects of parasitism such as Nutting suggests. Stems average about twice the height given by Nutting, but agree in being fascicled and in most other features. The hydranths are predominantly spindle-shaped rather than pyriform, with about fifteen filamentous tentacles, which are rather promiscuously distributed over the body of the hydranth, with no evidences of whorls.

Gonosome.—Medusa buds arise generally from independent branches and singly. As they approach maturity the general organogeny is easily made out. Four radial canals, numerous tentacles folded within the cavity of the bell; manubrium well developed, indicating a period of freedom during the life history; indeed, in handling the specimens they frequently became detached from their pedicels.

Genus **TUBULARIA** Linnæus

Trophosome.—Hydrocaulus with a tubular perisarc, usually unbranched, or irregularly and without annulations. Hydranths relatively large and flask-shaped, with a basal whorl of filiform tentacles, and a distal or oral series of similar shape, usually fewer in number.

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[4] Eped. Antarc. Belg. (1904) 8, fig. 2.

Gonosome.—Gonophores medusoid, though not becoming free, borne in racemelike clusters just above the basal tentacles. Eggs develop into actinulæ which are set free and attach themselves as young hydroids.

Tubularia crocea (Agassiz).

Specimens of a *Tubularia* taken at stations 846, 849, and 859 were fragmentary and undeveloped, but in all distinguishable respects closely resembled this species. Specimens were small, 30 to 40 millimeters in height, usually with only twelve to sixteen tentacles in each cycle. Gonophores rudimentary. All the specimens were supporting colonies of a symbiotic hydroid, as were many other species. These will be described in another connection.

Ectopleura dumortieri (Van Beneden). Plate 1, figs. 3 and 4.

Tubularia dumortieri VAN BENEDEN, Rech. sur l'Embryogenie des Tubulaires (1844) 50.

Ectopleura dumortierii AGASSIZ, Cont. Nat. Hist. 4: 343; ALLMAN, Ann. & Mag. Nat. Hist. III 13 (1864) 368; HINCKS, Brit. Hydr. Zooph. 1 (1868) 124; BROWNE, Proc. Roy. Soc. Ed. (1905) 748; HARTLAUB, Nord. Plankton (1907) 94; HARGITT, Biol. Bull. 14 (1908) 108; MAYER, Medusae of the World 1 (1910) 69.

This hydroid was taken at station 862, from a depth of 10 to 12 fathoms, in a fine state of development, and laden with medusæ almost ready to be set free. The specimens were somewhat larger than those I have seen before, yet otherwise seem indistinguishable from the above.

Trophosome.—Hydrocaulus simple or sparingly branched, about 50 millimeters in height; hydranth large, flask-shaped, with the two series of tentacles of filiform character in general, but the oral series occasionally somewhat capitate. Proximal, about thirty; oral, fifteen to twenty.

Gonosome.—Gonophores borne on long, branching pedicels with medusæ in various stages of maturity, the larger with two primary tentacles protruding from the bell, and a second pair visible. None mature enough to show the ectodermal zones of nematocysts.

I cannot agree with the assumption of Mayer that this species is in any specific respect identical with *Ectopleura ochracea.*

My description of the latter was published in 1904, and that of Mayer in 1910 in which he designates it as a synonym. In my description of *E. dumortieri* I designated it as perhaps a variety, namely, *prolifica;* but later comparisons of the descriptions of both Browne and Hartlaub (vide supra), convince me that it is essentially identical with the above, and especially is this sustained by the material here described. Having taken both species frequently at Woods Hole, and compared those with the specimens from the Philippines, I am thoroughly convinced of the validity and distinctness of the two species.

Genus **CORYMORPHA** M. Sars

Corymorpha symmetrica sp. nov. Plate 2, fig. 5.

The genus *Corymorpha* has generally a northern range, but recently Stechow[5] has described a specimen of this genus, *C. nana,* taken at Plymouth, England.

In the Philippine collection was found at station 2307 a hydroid which is undoubtedly a member of this genus; this goes to confirm Stechow's account just mentioned, and thus again shows that hydroids, like most organisms, may now and then be found far outside their usual range, in the present case very far removed from an Arctic environment.

At first sight it seemed to be fairly similar to *Corymorpha nana,* especially as described by Bonnevie,[6] and is thus especially significant in the light of Stechow's account; but closer scrutiny showed that it belongs elsewhere; indeed, it seems to be distinctly a new species, and also new for this genus from this region.

Trophosome.—Hydroid solitary, yet with stoloniferous growths from its base, forming apparently a distinct rhizocaulus, but I found no disposition toward the formation of colonies. The habitat is peculiar; it grows upon masses of a red coralline, which as a background made it very distinct and conspicuous; and in many cases the coral grew about the base of the hydroid. Its characters are distinctively true to type; stems with usual cœnosarcal canals, the peculiar perisarc of the genus, hydranths large and flask-shaped and rather sharply constricted at base; two series of tentacles, a basal series of from thirty to forty which are long and filamentous, depending chiefly on the age of the specimen, an oral series varying from twenty-four to thirty-six. Hydroid from 20 to 30 millimeters in height.

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[5] Journ. Marine Biology 9 (1910–13) 404–406.

[6] Norw. North-Atlantic Exped. (1876–1878) 1899, p. 22.

Gonosome.—Medusæ are borne just above the basal tentacles, and on peculiar peduncles, which at first seemed to be an elongate raceme with numerous medusa buds; but, in fact, the latter on my specimens appear to be relatively few, and what at first seemed very small buds were complexly branched masses of nematocysts, as shown in the figures. The largest medusa buds had no apparent asymmetry; no tentacles, but tentacular buds of similar size and position. In shape the medusæ are typical, apparently devoid of functional tentacles, and with faint pigmentlike granules on the outer side; radial and circular canals typical, but no specimen shows the character of manubrium or sex. Largest about 0.7 millimeter in height by 0.6 millimeter in diameter.

The marked symmetry of the medusæ, especially as compared with *Corymorpha nana* (Alder), its nearest relative, distinguishes it from any other known to me.

Genus **EUDENDRIUM** Ehrenberg

Eudendrium attenuatum Allman.

Eudendrium attenuatum ALLMAN, Hydroida of the Gulf Stream, Mem. Mus. Comp. Zool. 5 (1877) 6.

Allman's description of this species was based upon the naked stems and branches, neither hydranths nor gonads being present, and he gives it only a provisional name. The material at hand agrees very closely with the description of Allman, and I believe the species to be identical. I therefore add descriptions of the features lacking in the original account, and accept the name given there.

Trophosome.—The entire colony is distinctively of the *Eudendrium* type, hydrorhiza filiform and reticulate, stems slender, unfascicled, branching alternately, the branches annulated at origin as are also the pedicels; stem almost devoid of annulation except at its origin from the stolon, or only rarely above; hydranths of usual type, with from twelve to sixteen tentacles, hypostome trumpet-shaped in extension.

Gonosome.—The gonads are of the typical sort; females borne in a series on the ends of pedicels having arisen from the hydranth, usually degenerate or entirely aborted; male gonophores lacking in my material.

Taken from a cable at a depth of 100 fathoms, agreeing again in general with Allman's, which was dredged from a depth of 60 fathoms.

Eudendrium griffini Light.

Eudendrium griffini LIGHT, Philip. Journ. Sci. § D 8 (1913) 333.

My material was taken at stations 2145 and 2309, in shallow waters, attached to stones and seaweeds. Light's description is extended and renders unnecessary any extended account here.

Trophosome.—The hydroid is rather small, from 15 to 25 millimeters, borne on the usual reticulate stolons, stems mostly smooth with occasional annulations; hydranths relatively very large, with numerous (forty to fifty) tentacles, and with trumpet-shaped hypostome.

Gonosome.—This is of the usual type, though in the male only about two gonads on a given hydranth, and on opposite sides, with one or two chambers; in females, gonads borne on base of hydranth and of the usual type, though spadix not bifurcated as in *Eudendrium ramosum,* and as they approach maturity the pedicel weakening and falling upon the stem and becoming fused therewith.

This is a very interesting species among the many interesting ones known. *Eudendrium hargitti,* described by Congdon from Bermuda,[7] is hardly less so.

Genus **PENNARIA** Goldfuss

Pennaria tiarella McCrady.

Pennaria tiarella MCCRADY, Proc. Elliot Soc. Nat. Hist. 1 (1859) 153.

At stations 795 and 2306 colonies of *Pennaria* were taken which in all essential features I recognize as this species, though their state of development is not at that condition which would make the comparison wholly demonstrative, except if one would make such comparison with specimens in similar state. This I have been able to do with material from Beaufort, N. C., and the two show such close correspondence that I have no hesitation as to their identification. No details of description will be offered in this connection, since the species is too well known to call for such. It may be worth while to state that the specimens at station 795 were attached to *Zostera,* a habitat very common with this species, and one that fortunately corresponds very closely with species of this habitat from Woods Hole.

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[7] Proc. Am. Acad. Arts and Sci. 42 (1907) 463.

Pennaria pacifica Clarke.

Pennaria pacifica CLARKE, Mem. Mus. Comp. Zool. 35 (1907) 6.

From two stations, 779 and 2310, specimens were taken that are so closely similar in various aspects of structure that I have no hesitation in referring them to Clarke's species. They are rather sharply different as to the trophosome characters, the stems and branches being unlike those of the preceding species in the extent of annulation, the size, and aspects of the hydranth. Clarke[8] has so fully described this species that it is unnecessary to give any details here.

In view of some recently proposed revisions of species of *Pennaria* by Stechow[9] it seems both pertinent and rather imperative to enter some protest and correct certain obvious errors and misinterpretations of fact.

There need be no doubt of the fact that, in those earlier days when the taxonomist reckoned his success by the number of species described, the temptation to multiply species was responsible for much confusion; but, on the other hand, any hasty reaction and unwarranted nullification of long-standing and well-founded species must inevitably lead to further confusion. I was among the first to show the importance of giving critical attention to the influence of varied environmental conditions upon such plastic organisms as hydroids, in an early paper on the development of *Pennaria tiarella*.[10] On the basis of this study Clarke soon after took occasion to correct certain errors of his own (vide supra). Stechow's attempt to reduce all known species of *Pennaria* to a very few, or perhaps one, seems too radical and reactionary for serious consideration.

I have studied with much care the development of several species of *Pennaria*, and have compared the morphology of both the hydroid and the medusoid aspects of species from widely separated geographic and hence climatic regions, such as Australia, the Mediterranean, Philippine Islands, Porto Rico, Bermuda, Tortugas, etc. I believe that, while there are cases in which species have been founded on local variations, such as *P. gibbosa* and *P. tiarella*, which I sought to correct,[11] for the most part the species earlier established are based upon good characters. The contention of Stechow that temperature may be a serious disturbing feature in its relation to species may be well worthy of consideration, but his application of this to *Pennaria* is a direct reversal of the facts involved. For example, his attempt to interpret the liberation and free life of the medusæ of *Pennaria* as being due to the low temperature of deeper waters, while the fact that those with a habitat on eelgrass during midsummer do not liberate the medusæ is attributable to the higher temperature which lessens vitality, is the very opposite of what actually happens. In *P. tiarella* those liberating the medusæ in great numbers are the summer variety, while those which mature the medusæ in early summer and from deeper waters never liberate them. It is thus in *P. australis* also. During midsummer medusæ are liberated in enormous numbers and, as in *P. tiarella,* during early evening. In the case of *P. cavolini* the medusæ seem never to be set free. At two different times I have worked at the Naples laboratory during the height of the breeding season and, in spite of every effort to secure free medusæ of the species, I never succeeded in observing or taking them in the tow. Doctor LoBianca, an expert on the fauna of the Neapolitan waters, assured me that medusæ of *Pennaria* are never set free from the hydroid. It seems safe, therefore, to say that conditions of food or temperature can have little direct influence upon the very important point under review.

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[8] Mem. Mus. Comp. Zool. 35 (1907) 6.

[9] Zool. Jahrb. 32: 336.

[10] Bull. U. S. Bur. Fisheries 24 (1904) 32.

[11] Loc. cit.

In *Pennaria cavolini* the distinctions are sharper than in any other species at hand. The pedicels are constantly short, averaging about 0.6 millimeter, and are constantly and completely annulated. The hydranths are shorter than in the other species, and the medusæ fixed.

In *Pennaria australis* the general aspects of the hydroid are similar to those of the preceding, pedicels short, averaging from 0.6 to 0.7 millimeter, but with only about five annulations at the base; medusæ constantly free, and larger than in any of the other species.

In *Pennaria pacifica,* while the general features are similar to those of *P. tiarella,* again the pedicels are shorter, averaging from 1.4 to 1.6 millimeters, and with five or six annulations at the base.

In *Pennaria tiarella* there is a marked difference in these respects; pedicels slender and from 3 to 3.75 millimeters, with five or six annulations at the base.

CLADONEMIDÆ Gegenbaur, 1856

Genus **ZANCLOIDEA** novum

Trophosome.—Hydrocaulus well developed, branching, and with dense brownish perisarc; hydranths clavate, with conical or rounded hypostome; tentacles of two sorts, filiform, irregularly distributed over the body, in many cases heavily annulated and bearing numerous masses of nematocysts; a second series, few in number, orally situated, and capitate.

Gonosome.—Gonophores medusoid, with bell well developed, four radial canals, two marginal tentacles, provided with abaxial tuffs of nematocysts borne on stalks; exumbrella free of meridional rows of nematocysts; no ocelli.

Type, *Zancloidea philippina* sp. nov.

Zancloidea philippina sp. nov. Plate 2, fig. 6.

At a number of stations, among them 764, 850, 871, 879, and 883, were taken colonies of a hydroid of very unusual characters and most puzzling as to its systematic relations. Finally specimens were discovered which bore nearly mature medusæ whose characters at once showed affinities with the Cladonemidæ. Careful staining and mounting demonstrated in a few cases the protruding tentacles from the medusa, with the stalked nematocysts of *Zanclea* and *Gemmaria.* At first it was thought that in this hydroid we might have at last the long-sought hydroid stock of Gegenbauer's *Zanclea costata;* but the medusæ showed the presence of only two tentacles and, moreover, absence of the exumbrellar rows of nematocysts. Again, the hydroid characters differed in most respects from those of *Gemmaria,* the only genus in which the hydroid is really known.

Trophosome.—Hydrocaulus stout, 30 to 50 millimeters in height, irregularly branched, with dense brownish perisarc, generally smooth surface, but with a lamellalike structure, and with annulations only occasionally near base of stems or origin of branches. The interior of the perisarc occasionally shows indications of annular thickenings, similar to those figured by Hincks in *Zanclea implexa.* Hydranths very large, 3 to 5 millimeters in length by about 0.5 to 0.7 millimeter in diameter in larger regions; shape clavate, becoming larger toward the oral region; hypostome rounded, with capacious mouth. In one case two distinct hypostomes and mouths were present. Tentacles numerous and irregularly disposed over the entire body of the hydranth, chiefly filiform, with occasionally the appearance of a few capitate ones about the mouth; most of them definitely characterized by strong annulations composed chiefly of massed batteries of nematocysts, especially on the distal portions.

The characters of the hydroid will be seen to differ so markedly from those of the hydroids of *Gemmaria* as to exclude it from this genus; but the same is true when one tries to find any clearer affinities with other genera. As will be noted, the medusoid characters point strongly to the Cladonemidæ.

Gonosome.—The medusæ are borne over the entire body of the hydranth, each apparently on a single pedicel, though it is common to find the buds arising in clusters, and in some cases they seem to have a common basal peduncle, as I have shown in the case of *Gemmaria implexa* and as is also true of *G. gemmosa.* Some of the medusæ seemed to be approaching maturity, the tentacles being protruded from the bell, and in these cases showed clearly the stalked nematocysts mentioned above. Largest buds 0.5 millimeter high, by about half that in width. Color pinkish in preserved material, and in one case a note gave that as the color of fresh specimens.

While there can hardly be reasonable doubt as to the affinities of the species with the Cladonemidæ, it is likewise even less doubtful that we have to do with an undescribed species. This is particularly true of the hydroid whose distinctive characters differentiate it from any species or genus known to me. Except for the medusan characters, which are strongly suggestive of the cladonemids, it would be difficult to place it under any existing hydroid family. The characters of the hydranth have little indicative of any gemmarian affinities, and the facts that *Zanclea* was established solely on medusan characters, its hydroid being absolutely unknown to this time, and that *Z. implexa* has been adjudged by highest authority to belong to *Gemmaria* leave the genus *Zanclea* without a single clearly recognized hydroid stock. In making this statement I do not overlook the contention of Hartlaub[12] who would identify *G. implexa,* given by me in 1904, as a different species which he designates as *Z. hargitti,* basing the distinction upon the single question of the medusæ being distributed over the hydranth body and frequently several upon a single peduncle as contrasted with some earlier descriptions which designate them as borne upon a single pedicel and in a whorl below the tentacles—a contention altogether trivial in the face of facts familiar to anyone who has studied the colonies in the height of their breeding season. Having in an earlier paper[13] submitted a brief account of some facts related to this point, I do not deem it necessary to go into further details here.

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[12] Nord. Plankton 12 (1907) 115, 119.

Mayer[14] has discussed certain phases of this problem, and assigns a specimen of *Gemmaria gemmosa*[15] to *Zanclea costata* Gegenbaur, provisionally but wholly gratuitously. There are also several errors of fact in the account; for example, designation of McCrady's medusa as having four tentacles, and as being 6 millimeters in height by 4 millimeters in width—points absolutely unmentioned by McCrady. Further, it has been observed repeatedly that this species at Woods Hole comes to productivity with only two tentacles and with a maximum height of 1.7 millimeters.

Bigelow[16] describes these medusæ as having a maximum diameter of 1 millimeter, and having but two tentacles, but with ripe gonads, which indicates that they have attained full size. I may merely point out that while Bigelow refers to my earlier discussion of Hartlaub's views he curiously ascribes to me full agreement therewith, the very point against which I had strongly protested.

It remains to refer to a still later account bearing on our problem[17] which describes a medusa designated as *Zanclea implexa* which has four tentacles but differs in two other points from the species as known; namely, the lack of the exumbrellar perradial nettle rows, and the presence of well-defined abaxial, purple-red ocelli on the tentacle bulbs, characters absolutely unknown in any species described. In spite of these facts Neppi ascribes it without hesitation to the species above named, explaining the absence of the perradial nettle rows as probably attributable to their degeneration as the medusæ approximate maturity! He also gives the depth from which it was taken as 1,000 meters, a further fact hard to conceive of in a species distinctively of surface habitat!

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[13] Biol. Bull. 14 (1908) 100–106.

[14] Medusae of the World (1910) 87.

[15] Bull. Mus. Comp. Zool. 37 (1900) 35.

[16] Mem. Mus. Comp. Zool. (1909) 187–188.

[17] Neppi, Valeria, Adriatische Hydromedusen, Kais. Akad. Wiss. Wien 121 (October, 1912) 11.

Even among the best taxonomists the problems of these sections of Cladonemidæ are extremely perplexing. This I believe to be due largely to the unfortunate disregard of first principles of scientific taxonomy; namely, complete knowledge of the entire life cycle. This was long ago pointed out by such masters as Agassiz and Allman, the former giving expression to the idea in the following words, referring directly to hydroids:[18]

> A true regard for science ought to lead us to imitate the entomologists, who raise the larvæ of insects before naming them.

Only two years later the latter states:[19]

> It will assuredly seem strange that those principles of classification which have been acknowledged as the only sound ones, and which have been our guide in every other group of the animal kingdom, should be almost entirely ignored in our attempt at a systematic arrangement of the Hydroids.

Cladocoryne floccosa Rotch.

Cladocoryne floccosa ROTCH, Ann. & Mag. Nat. Hist. IV 7 (March, 1871) 228; ALLMAN, The Gymnoblastic Hydroids, London (1871) 380; DU PLESSIS, G., Mitt. Zool. Sta., Naples 2 (1881) 178; HARGITT, Biol. Bull. 17 (1909) 369.

Material collected at station 746 from a cable at a depth of 25 fathoms contained, along with other hydroids, a few colonies of this beautiful hydroid. The species agrees admirably with the descriptions of the above-named authors, the last excepted, and is further considered in a later section.

Trophosome.—Stems simple, from a reticular hydrorhiza, and averaging about 7 millimeters in height; hydranth prominent, with long and branched tentacles from its base, ten to twelve in number, and terminating in knobbed masses of nematocysts; a second whorl of about six simple tentacles about the mouth, ending in similar knobs.

The entire trophosome is well protected with a perisarc, extending to the base of the flask-shaped hydranth; it is mostly smooth, or with occasional annulations.

This material agrees in all essentials, including depth, habitat, etc., with that described by du Plessis (vide supra), but seems to lack the batteries of nematocysts which both he and Rotch describe as located between the tentacle bases on the body of the hydranth. I find no evidence of these in my material.

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[18] Natural History of the United States 4 (1862) 339.

[19] Ann. Nat. Hist. (May, 1864) 345.

Gonosome.—This is absent in my material, but du Plessis describes it very fully in his extended paper just referred to.

In this connection I desire to correct certain points of my former account (vide supra), wherein I described a form that I found on *Sargassum* at Woods Hole in 1909 and designated as a varietal form of *Cladocoryne floccosa,* which form I named *sargassensis,* from its habitat on this seaweed. At that time I was not aware of a species described by Allman[20] and named *C. pelagica* from its floating habitat. As I stated at the time, the species differed in several respects from *C. floccosa;* but, comparing it now with this material and the description of Allman, and that later of Inaba cited by Stechow,[21] I am convinced that the Woods Hole species is identical with *C. pelagica,* and take this opportunity so to designate it.

Clytia delicatula (Thornely).

Clytia sp. INABA (1890) figs. 34, 35.
Obelia delicatula THORNELY, Zool. Results 4 (1900) 453.
Campanularia delicatula JADERHOLM, Neue oder wenig bekannte Ostasiatische Hydroida (1902).
Clytia delicatula STECHOW, Hydroidpolypen der japanischen Ostküste Part II (1913) 65.

Specimens of my material were taken at station 2130, and agree in all essentials with the descriptions of the above-named authors. The confusion as to genus by both Thornely and Jaderholm was probably due to inadequate material, or misinterpretation of the nature of the gonosome. It remained for Stechow finally to clear up the case, using freely the description of Inaba.

My material was collected by Light in April, 1913, at Taytay, Palawan, and was growing upon barnacles (*Lepas*), which were attached to a piece of bamboo that had been washed ashore.

Clytia kincaidi (Nutting).

Campanularia kincaidi NUTTING, Hydroids from Alaska and Puget Sound (1899) 743.
Clytia kincaidi FRASER, Hydroids of Vancouver (1914) 146.

From stations 732 and 743, among other hydroids, were specimens which I believe to be of this species, though absence of gonosomes makes impossible an exact identification. In my material it was not easy to distinguish the deeply fluted hydrothecæ described by the above-named authors, yet in all other respects they agree.

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[20] Journ. Linn. Soc. 12: 251.

[21] Hydroidpolypen der japanischen Ostküste, Part II (1913) 50.

Clytia alternata sp. nov. Plate 2, fig. 7.

Material from stations 2310 and 2313, Port Galera, Mindoro, among other hydroids, contained a species which appears to be new.

Trophosome.—Hydrorhiza a creeping reticulum, stems rising to a height of 10 to 20 millimeters, sparingly branched, with hydrothecæ arising alternately, giving to the stem a somewhat geniculate aspect, and borne on long annulated pedicels, campanulate in shape, margins with about twelve very acute teeth, the distal portions of the walls very delicate and often appearing to be fluted; hydranths large, with about fifteen tentacles and rather conical hypostome, but poor preservation makes this point doutbful.

Gonosome.—Gonangia elongate, obconical and with distal portion abruptly truncate, borne in axils of the stem and hydranth, on short annulated pedicels; orifice smooth with slightly everted lips; medusæ borne in a single row along the blastostyle.

The species resembles somewhat *Clytia linearis,* but careful comparison only emphasizes the distinctness.

Clytia tubitheca sp. nov. Plate 2, fig. 8.

From station 765 was found a species of *Clytia* rather unique in the greatly elongated hydrothecæ, averaging about 0.6 millimeter in length by 0.2 millimeter in diameter. Gonothecæ, 0.5 millimeter in length by about 0.25 millimeter in diameter. Pedicels annulated, the entire length of stems being about 1 millimeter. Margins of hydrothecæ dentate with faint striæ parallel therewith, the entire theca being cylindrical, with a short constriction at the base to articulate with the pedicel.

Gonosome.—Sessile, elongate, rather clavate, and abruptly truncate, orifice smooth. Medusæ present in various stages of development.

This is the only species of *Clytia* known to me with distinctly cylindrical hydrothecæ, though Agassiz has described one, *C. cylindrica,* which is claimed to have such, but most of the published figures fail to show this.

A species described by Marktanner-Turneretscher has some resemblance to this one, but its trophosome shows distinct differences, and it is also doubtful in that no gonosomes are present.[22]

Clytia longitheca sp. nov. Plate 3, fig. 9.

The material containing this hydroid was taken at stations 732 and 874. On first study it seemed to conform in its trophosome character with Allman's *Obelia longicyatha*,[23] which was based upon the trophosome alone. It was later referred by Pictet to *Clytia*, but I have not seen his description, and depend upon those of Billard[24] and of Nutting[25] but have some doubt as to the identification after study of the present material. Except for the marginal teeth, which are single in Nutting's species, it compares well with that here described.

Trophosome.—The stems arise from a creeping stolon, somewhat reticular, at first simple but soon branching profusely, and often becoming fascicled by the downgrowth of tubes from the base of branches. Further reference is made to this in the description of *Obelia longitheca* below. Height of stems, 20 to 50 millimeters, hydrothecæ long, obconic, distal portions very delicate and hyaline, and margins with about ten pairs of acute teeth, becoming somewhat fluted parallel with the teeth; pedicels short and annulated, hydranth large, with about twenty long stout tentacles.

Gonosome.—Gonangia very long and club-shaped, medusæ in all aspects of development, some in process of escape from the gonangium.

The species is one of the largest known to me, and is very beautiful.

Obelia longitheca sp. nov. Plate 3, fig. 10.

Numerous colonies of an *Obelia* that seems to be new were taken at stations 690, 855, 864, 878, and 884. Except in size it has much in common with a hydroid described by Thornely as *Gonothyrea longicyatha*.[26] Her description was confirmed by Stechow in material obtained at the entrance of Uraga Kanal, Japan, 1904.[27] The absence of gonangia in his material, and what may have been a misinterpretation of the gonosome by Thornely, led both to assign the hydroid to *Gonothyrea*. I strongly suspect that it should have been assigned to *Obelia,* an impression that is strengthened by an admission of Thornely as follows:

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[22] Die Hydroiden des k. k. Naturhist. Hofmuseums Wien (1889) 215.

[23] Mem. Mus. Comp. Zool. **5** (1877) 10.

[24] Exped. Scientifique du Travail. et Talisman **8** (1907) 168.

[25] American Hydroids, Pt. III (1915) 58.

[26] Willey, Zool. Results, Pt. III (1900) 451.

[27] Hydroidpolypen der japanischen Ostküste, Part II (1913) 71.

> If what appears to be an external capsule is in reality an escaping medusiform zooid, the species may be an *Obelia.*

Trophosome.—Hydrocaulus large, 8 to 12 centimeters high, branching profusely, stems fascicled in older parts, and showing downgrowths of tubular structures similar to those described by the above-named authors for their *Gonothyrea.* This is not, however, a character of any specific note, since it is common in many species. Hydranths large and long, with about fifteen filamentous tentacles arising below the hypostome, which is trumpet-shaped but much longer than usual, as will be seen from the figures. Hydrothecæ very long and with about ten pairs of acute teeth about the margin, pedicels rather long and variably annulated, in many cases totally so, while in others they may comprise only the basal and distal parts. The size is also variable, especially in material from different stations. For example, those from station 690 were 0.9 millimeter long, pedicels averaging 0.35 millimeter, with annulation variable; in those from station 855, hydrothecæ averaged 1.18 millimeters long, pedicels about 0.5 millimeter; those from station 878 averaged about 0.9 millimeter long, pedicels about as in the others.

Gonosome.—Gonangia long, slender, and club-shaped, averaging 1 millimeter long by 0.25 millimeter in greater diameter; medusæ were present in the gonangia in large numbers and in all stages of development, some in process of escape with tentacles, about thirty in number, extended.

Allman has described an *Obelia longicyatha,*[28] but his account dealt with the trophosome only and the transfer of the hydroid by Pictet (see under *Clytia longitheca*) ; it has many points of likeness with the one here recorded but, for obvious reasons of distinction and to avoid confusion, I have proposed it as a new species under the above caption.

Obelia sp.?

An unrecognized species of *Obelia* was taken at station 737, at 24 fathoms, which seems worth while recording, though absence of the gonosome makes an attempt to determine its specific relations little more than guesswork. The trophosome is characteristically Obelian, stems from a filamentous rhizocaulus branching and with hydranths arising in axils, pedicels short, annulated, and with large hydrothecæ with undulating, or obscurely toothed, hydranth with about twenty filamentous tentacles. Gonosome absent.

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[28] Mem. Mus. Comp. Zool. 5 (1877) 10.

Obelia attenuata sp. nov. Plate 3, fig. 11.

At station 765, associated with several other hydroids, was found a species of *Obelia* apparently undescribed. In the general shape of its trophosome it resembles *Obelia longitheca,* yet in most other respects its characters are very different.

Trophosome.—Hydrocaulus simple or sparingly branched, very slender, about 15 millimeters high, hydrothecæ arising alternately, elongate obconic, margins with about ten pairs of bimucronate teeth like those of *Obelia longitheca,* 0.5 millimeter long, on short annulated pedicels. Base of stems occasionally fascicled.

Gonosome.—Gonangia elongate, clavate, ending abruptly, 0.55 millimeter in length by 0.2 millimeter in average diameter. Genital products apparently medusoid, but too young to afford positive characters, borne on a central blastostyle.

The above name is proposed with some doubt, and is given provisionally as a basis of record.

Silicularia rosea Meyen. Plate 4, fig. 12.

Silicularia rosea MEYEN, Ueber d. Leuchten d. Meeres (1834) 204.
Hypanthea aggregata ALLMAN, Hydroida of the Challenger Expedition, Pt. II (1888) 26.
Silicularia rosea JADERHOLM, Hydroiden aus Antarktischen und Subantarktischen Meeren (1905) 17; NUTTING, American Hydroids, Pt. III (1915) 91.

Colonies of this hydroid were taken at stations 857 and 867, all of them small but in good condition, though without gonangia; taken from a cable at depths of 60 and 150 fathoms. Stems simple, from creeping stolons, base of stems expanded into enlarged supporting portion and conical at the point of extension of the very slender and amber-colored stems or pedicels, so thickened as to obscure the inner cœnosarc. Hydrothecæ rather hemispherical, with greatly thickened walls and oblique margins, in many cases with a fissurelike expression of the lower obliquity of the cup. Entire height from 2 to 5 millimeters.

According to Nutting, "This genus is found only in the Southern Hemisphere, and most of the species are in the subantarctic region." On this basis the one here recorded will materially extend its distribution to the Northern Hemisphere.

Nutting makes Allman's *Hypanthea aggregata* synonymous with the species under consideration, but a comparison of their figures with my own will show considerable differences. I have some doubt as to their identity, yet hesitate to propose a new specific name, especially in the absence of the gonosome.

Silicularia minima sp. nov.

At station 2311 there was taken, with small colonies of *Obelia* and *Perigonimus,* an extremely small specimen of an undescribed *Silicularia.* Like the former species it has a symbiotic habitat on these hydroids. Like the former, also, the trophosome seems to comprise a stoloniferous, climbing mass from which the single peduncles arise, each with its hydranth. These are very minute, the former varying from 0.3 to 0.4 millimeter in height, hydranths and tentacles from 0.1 to 0.2 millimeter in length; the hydrotheca is rather shallow, bilateral, but attached to the peduncle direct, thus lacking the spherical annulus of the former species.

While there may be some uncertainty in giving to the species a distinctive name, in the absence of gonophores, still, with the distinctness of the hydranths and the extreme minuteness of the specimens, there can hardly arise confusion should later discovery fail to confirm its distinctiveness, and as a basis of record it seems desirable to designate it by the name here given.

Genus **HEBELLA** Allman

Generic characters.—Hydrocaulus a creeping, monosiphonic stolon. Hydrothecæ cylindrical, with entire margin, destitute of operculum, and with cavity differentiated from that of the peduncle.

Gonosome unknown.

Hebella corrugata (Thornely).

Campanularia corrugata THORNELY, Ceylon Pearl Oyster Fisheries & Marine Biology, Part II (1904) 114.

Hebella corrugata VANHOFFEN, Die Hydroiden der Deutschen Süd-polar-Expedition (1910) 314; STECHOW, Hydroidpolypen der japanischen Ostküste, Part II (1913) 105, 107.

This hydroid was very common among the material in this collection, taken at stations 793, 824, 839, 844, 860, and 893, and doubtless would have been noted in others also had critical search been made for it. It was always in association with other hydroids, perhaps parasitic. The stolons creep over the stems and branches, often in a complex way, but predominantly in a direction parallel to the stem or branch to which they are attached. Hydrothecæ very large, often curved, with corrugated walls and everted margins, and often reduplications; pedicels short and obliquely annulated. Hydranths rather elongate, with conical hypostome, and with about twelve tentacles. In my specimens hydranths always retracted. Gonosome unknown.

The species was first described by Thornely as *Campanularia corrugata,* and later identified as a *Hebella* by Vanhoffen. I have followed chiefly the account of Stechow as cited above.

Hebella contorta Marktanner-Turneretscher.

Hebella contorta MARKTANNER-TURNERETSCHER, Die Hydroiden des k. k. Naturhist. Hofmuseums (1889) 215, figs. 17*a* and *b*.

A species of *Hebella* taken repeatedly, associated with *Idia pristis,* and which I take to be identical with the one named above and described by its author from material reported from Singapore, also associated with *Idia pristis,* and especially recorded from stations 778 and 824. Hydrothecæ long, cylindrical, with everted margins, often contorted variously, which condition I was at first inclined to regard as due to mechanical distortion made during examination and, especially, by the technic of staining and mounting but which was later found to be due to some natural cause during the growth of the hydroid. Hydrothecæ 0.65 millimeter long by 0.2 millimeter in diameter, pedicels very short and plain; hydranths long and slender, with conical hypostome and about ten tentacles. The gonosome is unknown.

Filellum serratum (Clarke).

Laforea serrata CLARKE, Bull. Mus. Comp. Zool. 5 (1879) 243; BILLARD, Exp. Scient. du Travail. et du Talisman 8 (1907) 178.

Filellum serratum STECHOW, Hydroidpolypen der japanischen Ostküste, Pt. II (1913) 111, 112, fig. 85.

Like the preceding species, this was always associated with other hydroids, presumably as symbionts, and in most respects is conformable with the descriptions given by the above-named authors. The hydrothecæ are adnate for about half their length to the stolons, this portion being marked with rather definite serrations giving the appearance of sawteeth, probably due to the wrinkling of the tubes in those regions. The gonosome is unknown.

Genus HALECIUM Oken, 1815

Halecium lighti sp. nov. Plate 4, fig. 13.

This species was taken by Prof. S. F. Light at Port Galera Bay, Mindoro, attached to tubes of *Eunice* growing in the strong currents flowing in and out of the bay. In another jar were also specimens, numbered 2315, Galera Bay, attached to a coral clump, in strong current, evidently in the same locality, also collected by Light.

Light had recognized the fact that the hydroid was a new species and had in his description proposed for it the specific name *armatum*, based upon the presence in many hydranths of a pair of extra large tentacles, some of which seemed to be armed with especially large nematocysts; hence the name. Describing the hydranths he had stated "each hydranth bearing on opposite sides two shortened and thickened, curved, club-shaped tentacles (nematodactyls) armed along either side with a row of from 9 to 15 large nematocysts." This particular detail of his description proved to be only partly true, large numbers of hydranths being entirely devoid of these specialized tentacles, some having but one, and thus rendering the specific designation proposed very doubtful and even misleading. Light's description was, by his own option, turned over to me when the collection was assigned to me for investigation and complete report, with the suggestion that I use such part of his description as I found acceptable. This I am glad to do, and in acknowledgment of his courtesy in the matter I take pleasure in naming the species in his honor as indicated above. I am also taking advantage of certain of his details of description in the account of the species.

Trophosome.—Stems about 25 millimeters in height, fascicled in basal portions, branches regular, and both stem and branches divided by straight joints into internodes of approximately the same length; branches and hydrophores in same plane, the latter adnate for most of their length, and in many cases where extension or reduplication occurs extending outward with slightly everted margins. The series of punctæ, so characteristic a feature of many species of *Halecium*, are lacking or extremely obscure in this one. Light gives the dimensions of the hydrophores as about those of the stem of internode on which found; diameter of base of internodes at base of branch, about 0.12 millimeter; of stem, 0.15; length of internodes of stem, about 0.4; of branches, about 0.3.

Hydranths.—In general these are fairly comparable with those of many other species; long and nonretractile, resting on an expanded basal portion by which they are attached to the hydrophores. The shape of the hydranths is somewhat distinctive; the figures will give a fairly good impression of this feature. As will be noted, two rather marked constrictions occur, one just below the circle of tentacles, another just below the expansion upon which it is attached to the hydrophore where it is linked to the cœnosarc of stem or branch. The median region is beautifully spindle-formed, the whole comprising a graceful body including hypostome, tentacles of which the number varies from twenty-five to thirty-five; neck, body, base, and its attachment to the hydrophore as already noted. The color is white, both in life and in its preserved state, unless discolored by the preservative.

Gonosome.—In this species as yet wholly unknown.

The following discussion of the distribution of *Halecium* is that given by Light in the description referred to above:

> *Halecium* has a very wide bipolar distribution, being found in the colder and temperate waters of all seas. With this there are only three species known from the tropical seas and these all from the tropical Pacific. There is no doubt however that a more careful study of the hydroid fauna of the Tropics will reveal the presence of several more. Of the 57 described species of the genus, some of which are no doubt synonyms, the originals came from the following regions: Arctic and north temperate 39, distributed as follows: Alaska 6, Pacific coast of the United States and Puget Sound 6, Atlantic coast of the United States and Gulf Stream 6, Bermuda 2, North Atlantic 2, North Sea 1, Norway 2, British Isles 11, Adriatic 1, Antarctic and South Temperate including Southern Australia 14; Tropical Pacific 3.

While these do not comprise all known species, as to distribution they none the less show in a general way the scope of the *Halecium* fauna of the seas as known.

Idia pristis Lamouroux. Plate 4, fig. 14.

> *Idia pristis* LAMOUROUX, Hist. des Polyp. Coral Flex. Zoophytes (1816) 200 (English translation); BALE, Australian Hydroid Zoophytes (1884) 113, Further Notes on Australian Hydroids (1893) 104; ALLMAN, Hydroida of the Challenger Exped., Pt. II (1888) 83, pl. 39.

Specimens of this remarkable hydroid were taken at many stations, 685, 718, 744, 824, 839, 860, 2314, and others. While long known, as shown in the old account of Lamouroux, it has not been generally known. Specimens of the present collection are the first seen by me, and records of its distribution are rather few in the literature available. Bale reports it from some five localities about the coasts of Australia; Allman, from two localities of the Challenger account, Panay, P. I., and off Bahia; and Marktanner-Turneretscher, Philippines. In the present collection it is one of the commoner species. Its bathymetric range is from 15 to 30 fathoms as recorded by the above-named authorities.

Trophosome.—Stems erect, stout, attaining a height of 75 to 130 millimeters, though doubtless more; pinnæ alternate, rather regular, and divided into segments fairly well marked, but this feature is not very evident on the main stem, where it is often obscure or lacking. Allman's descriptions seem too regular and precise to apply to my specimens, as I have had occasion to point out in other connections, and I can verify the statement of Bale that his specimens of gonothecæ "differ considerably from specimens" described by Allman, whose figures seem to have been given for the sake of their picture value rather than as precise representations of actual structure.

Gonosome.—The gonangia are borne chiefly but not solely on the stem, as I have found many occurring on pinnæ as well. The figure given is an accurate sketch of a female gonangium; that of the male is slenderer and slightly longer and somewhat less deeply fluted than in the female. In this distinction I am giving what appear to be male and female organs, but the material is not such as to afford an actual demonstration. My specimens fail to show the puncta emphasized by Allman, but not described by others. On the neck of the gonangium are frequently found small particles adhering to the capsular surface, but they are not at all comparable with the puncta of *Halecium*. Again, my specimens show transverse wrinkling of the capsules, as figured by Busk and as given by Bale in his account. Moreover, in my specimens the longitudinal flutings are less numerous than as given by Allman, averaging about ten, often less and rarely over twelve, while he gives sixteen in his figures.

Genus **STEGAPOMA** Levinson

Stegapoma medusiformis sp. nov. Plate 4, fig. 15.

Campanularia fastigiata ALDER, Ann. & Mag. Nat. Hist. III 5 (February, 1860) 73.

Calycella fastigiata HINCKS, A History of British Hydroid Zoophytes (1868) 208.

Stegapoma gracilis NUTTING, Hydroids of the Hawaiian Islands, Bull. U. S. Fish. Comm. (1905) 944.

At stations 854 and 866 were found several colonies of this very interesting and beautiful hydroid, the first of its kind to come under my direct observation. They were taken from a depth of 110 fathoms, and in every case were attached to other hydroids, parasitic (?) in relationship.

Trophosome.—Made up of creeping stolons, simple pedicels, and hydrothecæ, growing over stems of *Obelia,* usually standing out at a right angle from the supporting hydroid. The pedicels are slender, about as long as the hydrotheca, which measures in large specimens about 1.6 millimeters in length by 0.32 millimeter in diameter in the middle region; operculum made up of a series of strips which meet in a rooflike ridge at the top of the theca. Hydranths large and elongated, with conical hypostome and about twelve filiform tentacles, apparently supported by a diaphragm as shown in the figure, though it was difficult to demonstrate.

Gonosome.—The gonangia are long and club-shaped, sessile from the stolon, and 3.5 to 4.2 millimeters long by about 0.6 millimeter in median diameter. Blastostyle lateral and bearing medusæ in various stages of development. So far as I am aware, these have not been described heretofore. In my specimens they show their distinctive medusoid characters, as fig. 15 will show, and sections made in both long and short directions confirm the surface aspects. These sections fail to show the presence of germ cells at this stage, which implies that the medusæ are liberated and lead a free life for a time and that the sex cells are set free during this free-living stage. The form of the medusa is fairly typical, bell rather high and narrow, with gastric structures of usual form and structure, with few tentacles; only two show in specimens within the gonangia. I regret the preservation was not such as to afford good microscopic structures, but these were sufficient for the study of the general morphology.

In general the species here described agrees very well with those referred to above, but it agrees more closely with that of Nutting, *Stegapoma gracilis*; yet there appear features which differ from it. I am disposed to suggest that on the basis of the distinctive medusoid characters, and the larger size of the gonangia, it be designated as a new species.

Genus THUIARIA Fleming

Thuiaria tubuliformis (Marktanner-Turneretscher). Plate 4, fig. 16.

Dynamena tubuliformis MARKTANNER-TURNERETSCHER, Die Hydroiden des k. k. Naturhist. Hofmuseums Wien (1890) 70.

Thuiaria tubuliformis NUTTING, American Hydroids, Pt. II (1904) 70.

The material was taken at several stations, among them 761, 793, and 817. The colonies were mostly small and none more than 40 to 50 millimeters in height. Trophosome made up of a reticulate mass of stolons from which stems grew erect, but with a definitely geniculate aspect from the alternate origin of the branches; this was particularly apparent in younger specimens and distally; hydrothecæ tubular and deeply immersed in the stem, less so on branches, the distal portion facing outward, the aperture closed by two valves which meet at the two opposite teeth of the theca. In my specimens the hydrothecæ are arranged in pairs, varying in number for each internode from two to four or five, giving the branches a distinctly segmented aspect, resembling somewhat *Pasythea,* a fact not shown in Nutting's figures nor mentioned in his descriptions. In fact, my specimens agree more closely with those described by Marktanner-Turneretscher than with Nutting's account. I regret that no gonangia were found in my collection, nor does the earlier author describe them. Nutting's figures are difficult to understand, since he gives three drawings of the gonangia, all different; in two the orifice has straight margins, in the other the margin is very much everted. Again, his figures of the stems and branches show such great difference that they might almost be considered as from different species, a fact which perhaps may illustrate how inadequate are trophosome characters in many cases as a basis of specific determination.

Thuiaria quadrilateralis sp. nov. Plate 5, fig. 17.

At station 736 was taken a species of *Thuiaria* which does not seem to have been described; at any rate, I am unable to identify it with any known species.

Trophosome.—Colony rather stout, stems arise from a reticulate series of stolons, to a height of 30 to 50 millimeters with branches alternating from successive internodes, each of which bears three hydranths, the pinnæ arising just below the third hydranth of the internode; hydrothecæ tubular and deeply submerged in stem and branch, with apparently valves attached to inner and outer margins.

Gonosome.—Gonangia large, several times the size of hydrothecæ, of four-sided shape, borne on short pedicels of pinnæ, none on stems of my specimens. The quadrilateral aspect of these organs is rather unusual, and so far unknown among the *Thuiaria.* The specific name is proposed from this character.

Genus SERTULARIA Linnæus (in part)

Sertularia minuta sp. nov. Plate 5, fig. 18.

This hydroid was taken at station 697 along with fragments of several other hydroids. It is a very minute species, yet apparently mature, as there are numerous gonangia.

Trophosome.—The stems are simple, with no signs of branching in any specimen; they arise from creeping stolons, which also bear the gonangia. Height of colony, 4 to 7 millimeters, each bearing from four to six paired hydrothecæ on the upper portion of the stem, which is regularly divided into internodes each with a single pair, adnate for about a third of their length, tubular, the distal part strongly divergent and with apparent abcauline valve; though the delicacy of these terminal portions makes difficult an exact demonstration, in some cases two valves seemed present. Hydranths long and very slender, but preservation was not such as to make structural features demonstrable.

Gonosome.—Gonangia arise from the stolons, though close to the base of a stem, in some cases seeming to attach to the stem, but this was doubtful; the shape is broadly spindlelike, and deeply and regularly corrugated, as shown in the figure, with rather large aperture, from which in some specimens embryos were in process of liberation.

This species has some points of resemblance with *Sertularia pourtalesi,* but in size and shape of hydrothecæ there are strong differences, especially as described by Allman and Nutting, the figures of Marktanner-Turneretscher being much nearer my species.

Sertularia dubia sp. nov. Plate 5, fig. 19.

This minute hydroid was taken at station 2308, Port Galera, Mindoro. No gonangia were present, and the specimens are apparently young, but I am not able to identify the species with any known to me; so, for purposes of record, I propose the name *dubia* to distinguish it.

The stems are simple, composed of regular internodes, each with a single pair of hydrothecæ which are relatively large, and with correspondingly large hydranths, each with about fifteen to twenty tentacles. The hydrothecæ have their distal portions strongly divergent, as in the previous species, and with a two-valved operculum.

Sertularia sigmagonangia sp. nov. Plate 5, fig. 20.

The colonies of a hydroid, apparently new, were taken at stations 704 and 2310, from a cable at the north shore of Batan, at depths of 15 to 177 fathoms.

Trophosome.—Stems erect, rigid, with branches at right angles of stem and also rigid and ungraceful; color brown, perisarc dense; hydrothecæ of stem alternate, those of branches strictly opposite, rather retort-shaped, and two opercular valves not easily distinguishable; hydrothecæ face directly outward, but those of stem just below origin of branch recurve downward in many cases.

A point of some importance is the rather constant reduplication of the margins of hydrothecæ, which does not appear in *Sertularia versluysi,* the species most nearly resembling it.

Gonosome.—These organs are elongate and fusiform, but rather sigmoid in general outline, due apparently to the direct outgrowth, then an upgrowth, and finally a curving of the distal portion with orifice facing directly outward, the margins ending in some four inconspicuous teeth, the whole gonangium deeply corrugated and some three or four times the length of the hydrotheca, 1.7 and 0.6 millimeter in length and diameter at broadest part, respectively.

I believe the species to be new and propose for it the name suggested by the shape of the gonangium.

Genus **SERTULARELLA** Gray

Sertularella gayi? Plate 5, fig. 21.

At station 768 were taken fragmentary colonies of a hydroid resembling somewhat *Sertularia annulata* of Allman,[29] yet differing in some respects. The stems are straggling, irregularly branched, and indefinitely divided into internodes; hydrothecæ alternate, usually two to each internode, divergent from stem or branch and narrowing to four-angled margin, with four teeth and a four-valved operculum, distal and upper part of thecæ corrugated. No gonangia on my specimens. In some aspects it resembles *S. gayi?*; yet, as stated above, with strongly marked differences. I merely list it for record under this name.

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[29] Hydroida of the Challenger Exped. (1880) 52.

Sertularella philippensis sp. nov. Plate 6, fig. 22.

At stations 729, 788, and 882 were taken hydroids of this species, the best and most typical coming from 882.

Trophosome.—Stems from reticular stolons attached to rocky fragments, dense and stout, yellowish brown, profusely branched and in alternating order, as are the hydrothecæ of both stem and branches, divided into fairly regular internodes by indistinct nodes; hydrothecæ rather short and broad with apparently four-valved openings, the valves difficult to demonstrate; hydranths short, with some fifteen tentacles, body in expansion round, but in contraction folded or retortlike.

Gonosome.—Gonangia are large, 2.5 millimeters long by about 0.8 millimeter in diameter, and with broad aperture and three strong and prominent marginal teeth.

Sertularella punctagonangia sp. nov. Plate 6, fig. 23.

At station 884, from a depth of from 65 to 150 fathoms, along with large masses of *Obelia longitheca,* there were taken specimens of a sertularian which seemed quite new, and careful scrutiny of available literature confirmed this impression. The hydroid is a beautiful one, both as to form and structure, as will be noted in the description and figure given.

Trophosome.—The specimens were from 50 to 75 millimeters in height, stems slender, amber color, more or less erect and with alternate branches, also delicate and relatively long and curving gracefully, the ends attenuate. Hydranths of stem alternate, a single one occupying the axil of each branch, but those of the branches more or less opposite in position, all of delicate hyaline aspect, and facing outward, tubular and attached for about a third of their length to stem or branch, then curving to a narrowed orifice with what appears to be a single abcauline valve. Hydranths elongate, slender, and attenuate, with conical hypostome, and fifteen to eighteen, delicate, long, and threadlike tentacles. Stems and branches irregularly annulated, but not showing definite divisions into segments.

Gonosome.—The gonangia are numerous, relatively large and with smooth transparent walls, and borne on stems, occasionally on branches, usually attached just below a hydrotheca. They are elongate, urnlike structures, with slightly everted margins, each with a convex lidlike operculum, hinged at one point. The beauty of shape is heightened by a series of glistening puncta, variable in number, around the outer shallow constriction, as shown in the figure. So far as I am aware, this is the only instance of such puncta in the Sertularidæ. In these specimens the gonangia were apparently male.

As will be noted, the description given of the hydroid shows characters not entirely peculiar to this genus, such as both alternate and nearly opposite positions of the hydrothecæ on stems and branches, respectively, and the distinctly unusual aspects of the gonangia. Since it does not appear to be better allied elsewhere, it is tentatively placed here as designated above.

Genus **SYNTHECIUM** Allman

The following is Allman's characterization of the genus which he established in 1888: Trophosome, stem divided into regular internodes, each of which carries a pair of opposite hydrothecæ, or a single one which alternates with those of the adjacent internodes; hydrothecæ adnate for about half their length with the mouth facing outward and with margins everted and often reduplicated.

Gonosome.—Gonangia borne on peduncles which spring from the interior of cavity of certain hydrothecæ where they replace the hydranths.

Synthecium flabellum sp. nov. Plate 6, fig. 24.

Several colonies of this hydroid were taken at station 715, Mindanao. The specimens were mostly small, some having a height of 30 to 40 millimeters, but others not more than 15 millimeters. Branching is usually opposite and in the same plane, and frequently terminates in elongate filaments, much as in *Diphasia* and many other hydroids; hydrothecæ opposite and adnate for about half their length, margins smooth and mostly reduplicated. In my specimens the hydranths were badly preserved and the characters not determinable.

Gonosome.—Gonangia were borne on both stem and branches, and in these specimens mostly female, ova being recognizable in a looplike spadix not unlike those of *Eudendrium ramosum,* the whole inclosed in the gonangium which is spindlelike but rather depressed and podlike. In certain specimens which appeared to be male, though too poorly preserved to enable one to determine it, there was less of flattening and the generative mass was centrally located.

In these specimens I am unable to confirm certain of the features emphasized by Allman. For example, I often find branching to be alternate, or only a single branch appearing on a given internode, and this is very usual with secondary branches. Again, I find that these branches may arise just as in other hydroids, but also in a telescopic aspect as mentioned by Nutting in *Synthecium rectum*.[30] I also find similar variation as to the hydrothecæ, usually opposite and regular, but frequently single and more or less irregular. I find the same variation as to gonangia. In the main they are as described in the original generic account, but not infrequently they arise without the appearance of the hydrothecal envelope, just as with a branch. I am quite inclined to agree with the contention of Torrey[31] that the origin of the gonangia here is not the unique feature Allman has claimed.

Genus **PASYTHEA** Lamouroux (in part)

Pasythea griffini sp. nov. Plate 6, fig. 25.

At stations 771 and 794 were taken colonies of a hydroid of an unknown species. Its generic characters were unmistakable, and except in size its general appearance was similar to *Pasythea nodosa* or *P. quadridentata;* but there were sharp differences, the most convincing being the gonangia which were unlike any known.

Trophosome.—Stems mostly simple, but occasionally branching, as noted in *Pasythea nodosa;* borne on creeping stolons which on eelgrass often made a loose reticulum, but those on mollusks did not show this; height of stems from 4 to 9 millimeters, and as in other species, the lower segment frequently with a single pair of hydrothecæ, the upper ones with from two to four pairs. It differs from other species known to me in that the nodes are not oblique but square, forming usually a joint resembling an annulus of the form very characteristic of hydroid stems, and the internodes are very short, differing sharply in this character from other species. Another feature was rather interesting as showing its possible mode of differentiation to the typical sertularian type; namely, that rarely the stem may have but a single pair of hydrothecæ on each internode.

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[30] American Hydroids, Pt. II (1904) 135.

[31] The Hydroida of the Pacific Coast of North America, Univ. of Cal. Publ. Zool. 1 (1902) 62.

Gonosome.—The gonangia of this species are very distinctive. They usually arise from the basal internode, but they also arise from other internodes; occasionally three were noted on the basal node, those above usually single; the shape is rather urnlike, with a very short pedicel, outline smooth, and with an elongate, rather narrow neck curved outward and with beautifully everted margin, as shown in the figure.

A species, described from the Philippines by Marktanner-Turneretscher and probably quite distinct though no gonangia were present, is similar in size to *P. griffini*, but they have few characters in common.

In this connection, I may direct attention to the fact that, since the original description of *Pasythea nodosa*,[32] I have carefully compared that material with material of later date, which is identical with the original descriptions of *P. quadridentata*, and find the distinctive trophosome differences very well marked. The later identification of material by Stechow [33] with *P. nodosa* still further confirms the species, allowing for possible modifications which may come from discovery of the gonosomes.

Genus **PLUMULARIA** Lamarck (in part)

Plumularia ramsayi Bale.

Plumularia ramsayi BALE, Australian Hydroid Zoophytes (1884) 131.

From station 2311, in June, 1913, Light collected a few fragments of several hydroids, chiefly *Idia pristis*, a *Eudendrium*, an *Obelia*, and small colonies of the above-named hydroid which, though fragmentary, were fairly well preserved. The colonies were devoid of gonangia. They were, however, sufficiently distinct to reveal fairly definite specific characters, which made possible the recognition of the close relationship of this hydroid to Bale's species, though they differed in several points; for example, in the branching which is very regular in my specimens and alternate in others. On this point Bale states that there is "no regularity in their arrangement, as they may be either opposite or alternate, and there are often two or three branches on one side to one on the other." However, the specimens at hand are too few and fragmentary to warrant contention, and as Bale's description designates the species as "extremely variable in habit," it seems better to accept his account than to attempt a detailed description from the material in my possession.

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[32] Biol. Bull. 14 (1908) 114.

[33] Hydroidpolypen der japanischen Ostküste, Part II (1913) 150.

Plumularia sp.?

There was another, very small fragment from Taytay, Palawan, of a *Plumularia* of doubtful specific relation, though very distinct from the preceding one, and altogether too fragmentary to warrant any attempt at specific determination. It seems to be very young, rising to only 4 to 6 millimeters in height, branching dichotomously, and supported from a filamentous stolon.

The accounts here, and that of Busk describing *Plumularia effusa*, listed by Bale,[34] seem to be the only records of *Plumularia* from the Philippines.

Genus ANTENNELLA Allman

Antennella gracilis Allman.

Antennella gracilis ALLMAN, Mem. Mus. Comp. Zool. 5 (1877) 38; NUTTING, American Hydroids, Pt. I (1900) 77.

At stations 749 and 798 colonies of the above-named hydroid were obtained from the submarine cables near Calbayog, at depths of 49 to 54 fathoms. In all essentials except size the specimens agree well with the descriptions of Allman. My specimens averaged only about 12 millimeters in height, and unfortunately were devoid of gonangia, which thus far are unknown. Following Allman, Nutting regards the species as stemless, that which appears to be stem being considered a hydrocladium arising direct from the stolons. It is not clear that this view has any particular value. Why not as well designate it as a case of variation, or perhaps better, mutation, or even regression, or other expression of adaptation, as Hincks has very strongly suggested concerning *Plumularia secondaria*? [35]

Genus SCHIZOTRICHA Allman

Schizotricha philippina sp. nov. Plate 6, fig. 26.

A very delicate and beautiful hydroid was taken at station 839, but no data as to depth or other particulars were recorded.

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[34] Op. cit. p. 130.

[35] A History of British Hydroid Zoophytes (1868) 304.

Trophosome.—The hydroid is a very delicate one, about 25 millimeters in height, the stem arising from reticular stolons; the main stem has annular segments in the basal part, and above is divided into fairly regular internodes, the joints being both square and oblique; hydrocladia sparingly branched, usually only once; hydrothecæ cuplike, one to each internode, and with a nematophore just below and a pair attached to the base of the theca.

Gonosome.—The gonangia are curved cornucopialike, resembling those of *Schizotricha tenella,* but with relatively broader openings, attached by very short pedicels to the hydrocladium just below the base of the hydrothecæ; walls are very delicate and collapse under the slightest pressure, and are apparently devoid of nematophores.

So far as known to me, this is the first record of a member of this genus from the Philippine Islands.

Genus **DIPHASIA** Agassiz

Diphasia digitalis Bale.

Desmoscyphus longitheca ALLMAN, Mem. Mus. Comp. Zool. 5 (1877) 26.

Diphasia digitalis BALE, Australian Hydroid Zoophytes (1884) 101; NUTTING, American Hydroids, Pt. I (1900) 110.

At stations 781 and 893 were taken sterile colonies of a species which is in all essentials identical with that above named, at least so far as trophosome characters are concerned. The colonies were more or less fragmentary, attached to fragments of coral rock, seaweed, etc. They were apparently small, about 25 millimeters in largest specimens, while Nutting gives the height as 4 inches. The branching was not regular, with no secondary branches such as figured by Allman. The presence of long terminal growths or filaments was strongly marked in some cases, which is a well-known character of other species also.

Genus **THYROSCYPHUS** Allman

Thyroscyphus simplex Allman.

Thyroscyphus simplex ALLMAN, Hydroida of the Challenger Exped., Pt. II (1888) 25.

At stations 769, 792, and 893 were taken colonies of a hydroid which I identify as *Thyroscyphus simplex,* though no gonangia were present; indeed, none have been described, so far as I am aware. Several features in my material differ from the descriptions and figures of Allman. In several instances I have had occasion to criticize the mechanical aspects of his figures, and in this species his figures differ very much from my specimens. For example, the stems are often devoid of distinguishable segmentation; again, one set of specimens, those from station 769, had hydrothecæ of very different form from that of specimens from the other stations named above. In other respects they were quite alike; so I interpret the widely divergent hydrothecæ in these as an individual peculiarity attributable to conditions of growth or environment, and would also so interpret the differences of nodes, the excessive thickenings of the stems or branches having more or less obscured the joints.

Aglaophenia macgillivrayi (Busk).

Plumularia macgillivrayi BUSK, Voyage of the Rattlesnake (1852) 400.
Aglaophenia macgillivrayi ALLMAN, Voyage of the Challenger, Zool., Pt. I (1883) 34; MARKTANNER-TURNERETSCHER, Die Hydroiden des k. k. Naturhist. Hofmuseums Wien (1889) 268.

From stations 873, 897, and 898 several fine colonies of this rather remarkable hydroid were taken from the reef near Mindanao, at a depth of 8 to 10 fathoms. The species was first described by Busk as *Plumularia macgillivrayi;* the next account is that of Allman, in which he describes in much detail a very large specimen, "upward of fifteen inches high." My specimens averaged about 20 centimeters.

Trophosome.—Colony massive, stem thick, fascicled, with numerous opposite branches, all devoid of hydrothecæ; secondary pinnæ and hydrocladia, the latter with rather deep hydrothecæ having smooth margins; median and lateral nematophores, the median adnate to the hydrotheca and not extending beyond its margin, the lateral rather broad and extending beyond the margin of the hydrotheca. An interesting feature of some of these specimens was the presence of stolonlike outgrowths from upper and terminal portions of stems and branches, especially where some evidence of injury was apparent.

Gonosome.—Corbulæ similar to those of other species, borne on primary or secondary pinnæ, but never on the stems. In these specimens there was no distinguishing evidence of sex.

The extended description and excellent figures of Allman cited above render unnecessary fuller details here.

Genus **LYTOCARPUS** Kirchenpauer

Lytocarpus philippinus Kirchenpauer.

Lytocarpus philippinus KIRCHENPAUER, Ueber die Hydroiden der Familie Plumularidæ (1888); MARKTANNER-TURNERETSCHER, Hydroiden des k. k. Naturhist. Hofmuseums Wien (1889) 274; NUTTING, American Hydroids, Pt. I (1900) 122.

From station 803 were taken hydroids of a species which seems identical with that named above, though there are several points of difference, as will be noted.

Trophosome.—Stems coarse, fascicled in lower portions, and with a height of 8 to 15 centimeters, ascending from a knotted rootlike mass of fibers. Colony branching alternately, with pinnate hydrocladia directed forward and upward; hydrothecæ arranged rather closely, each with a deep constriction anteriorly, median and lateral nematophores of the usual form but differing somewhat from Nutting's description, the median ones extending beyond the hydrothecal margin, while the lateral ones do not extend much if any beyond it.

Gonosome.—The gonangia are ovoid, flattened laterally, the capsular walls rather thick but transparent; usually a single gonangium borne on the greatly reduced phylactocarp, but occasionally two. No distinction as to sex was apparent.

While the differences named are not great, they involve both gonosome and trophosome. Still I am inclined to regard them as not of sufficient importance to warrant any definite pronouncement of more than varietal values.

Lytocarpus sp. ?

At station 896, from a cable at a depth of 45 to 54 fathoms, near Samar, colonies of a large hydroid were found which apparently belongs to this genus, though absence of gonangia makes it difficult to be certain, the trophosomal characters being very similar in this genus and in *Aglaophenia.*

Trophosome.—Colony large, ascending from a mass of rootlike fibers, with a height of about 30 centimeters. Stems fascicled, devoid of nematophores or hydrothecæ, branches alternate, and with beautiful pinnate hydrocladia with an average length of about 10 millimeters. The hydrothecæ are rather deep and cuplike, with undulating or crenular margin, the anterior having a spinelike tooth.

Gonosome lacking.

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ILLUSTRATIONS

[All figures, except 4 and 14, are magnified about 24 diameters.]

PLATE 1

FIG. 1. *Bougainvillia philippensis* sp. nov.
2. *Perigonimus scandens* sp. nov.
3. *Ectopleura dumortieri* (Van Beneden).
4. *Ectopleura dumortieri,* portion of gonophore, highly magnified.

PLATE 2

FIG. 5. *Corymorpha symmetrica* sp. nov.
6. *Zancloidea philippina* sp. nov.
7. *Clytia alternata* sp. nov.
8. *Clytia tubitheca* sp. nov.

PLATE 3

FIG. 9. *Clytia longitheca* sp. nov.
10. *Obelia longitheca* sp. nov.
11. *Obelia attenuata* sp. nov.
12. *Silicularia rosea* Meyen.

PLATE 4

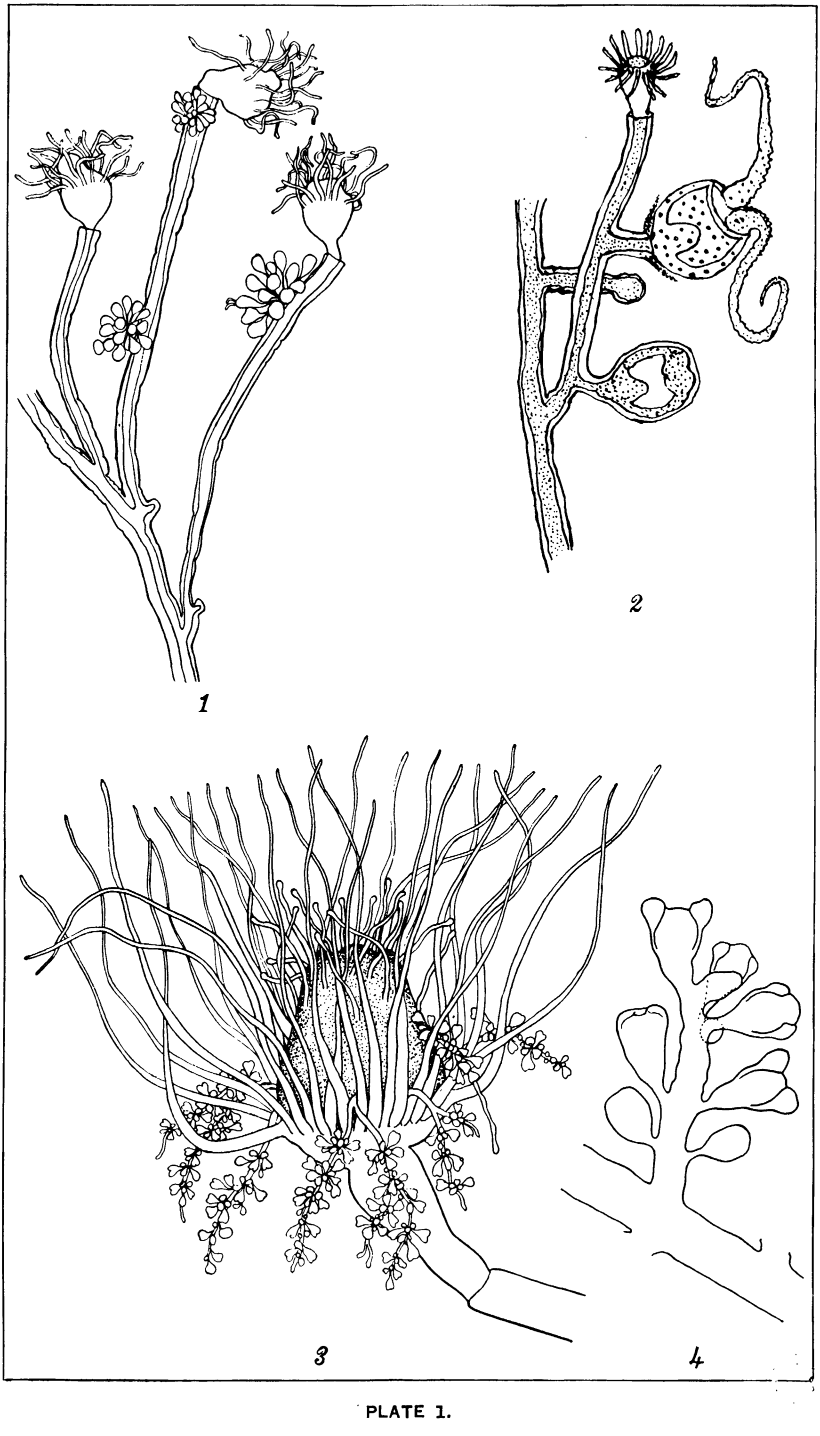
FIG. 13. *Halecium lighti* sp. nov.
14. *Idia pristis* Lamouroux, gonangium, magnified.
15. *Stegapoma medusiformis* sp. nov.
16. *Thuiaria tubuliformis* (Marktanner-Turneretscher).

PLATE 5

FIG. 17. *Thuiaria quadrilateralis* sp. nov.
18. *Sertularia minuta* sp. nov.
19. *Sertularia dubia* sp. nov.
20. *Sertularia sigmagonangia* sp. nov.
21. *Sertularella gayi* ?

PLATE 6

FIG. 22. *Sertularella philippensis* sp. nov.
23. *Sertularella punctagonangia* sp. nov.
24. *Synthecium flabellum* sp. nov.
25. *Pasythea griffini* sp. nov.
26. *Schizotricha philippina* sp. nov.



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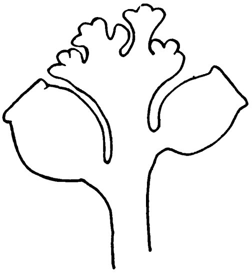

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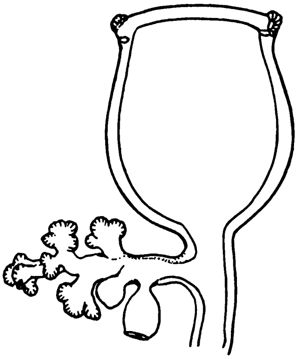

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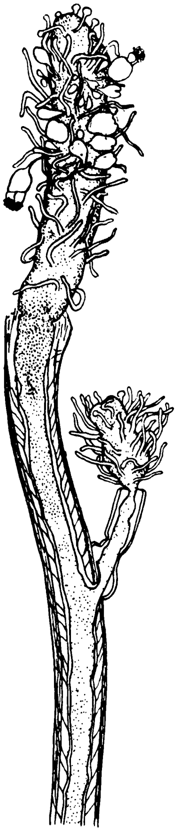

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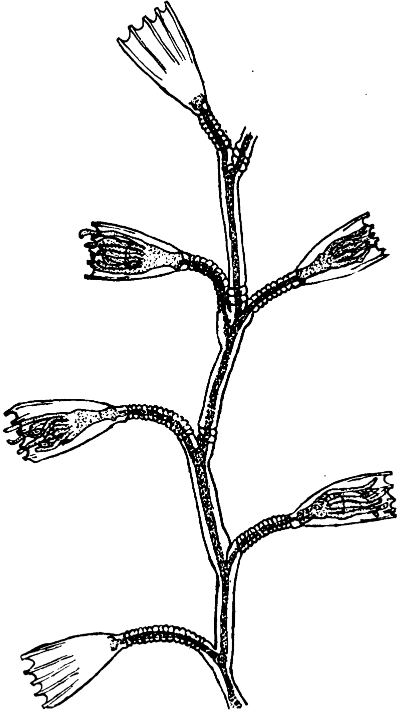

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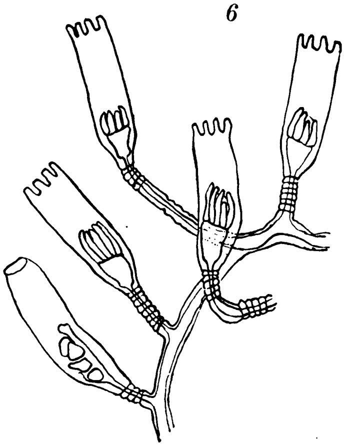

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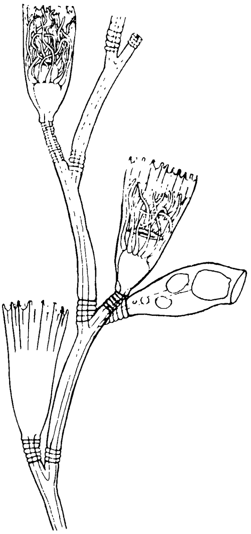

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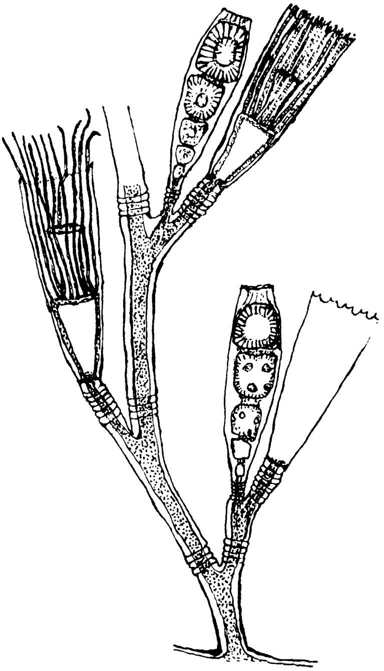

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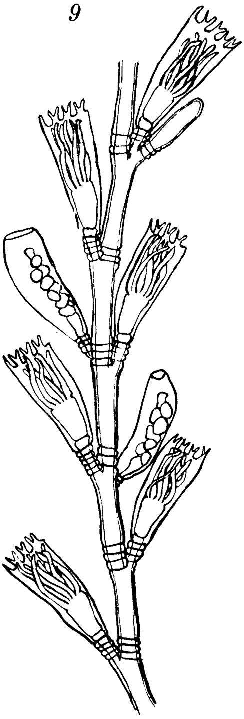

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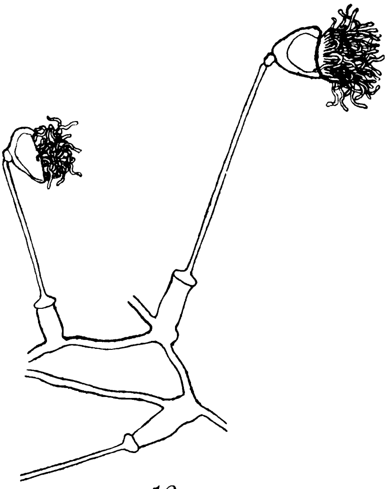

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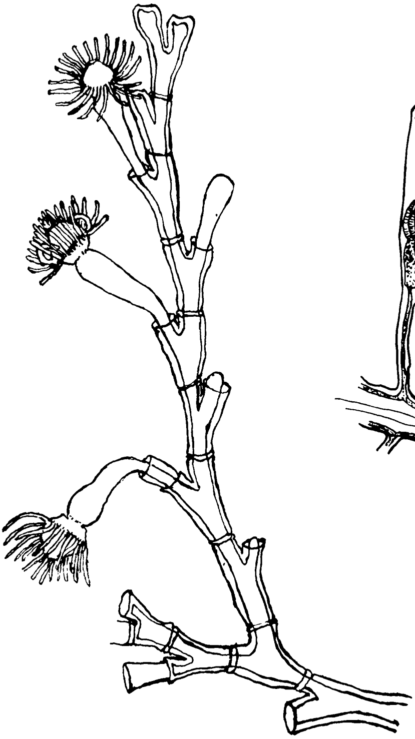
PLATE 3.



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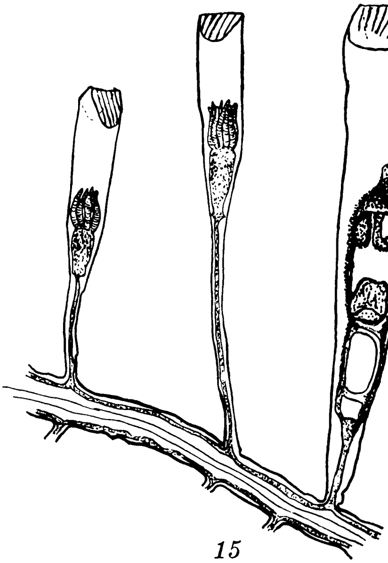

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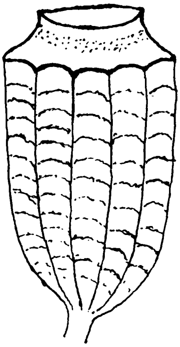

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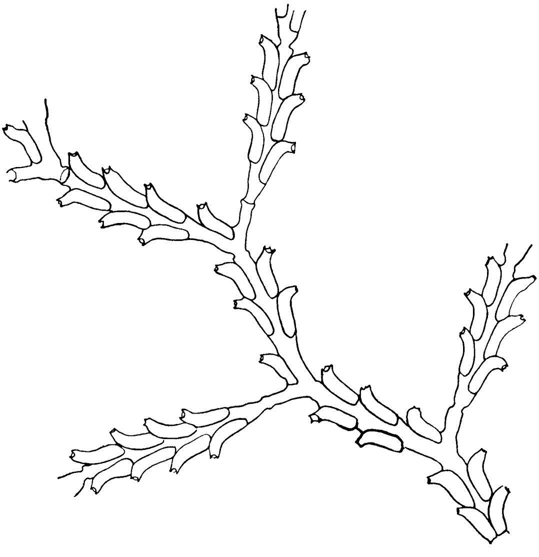

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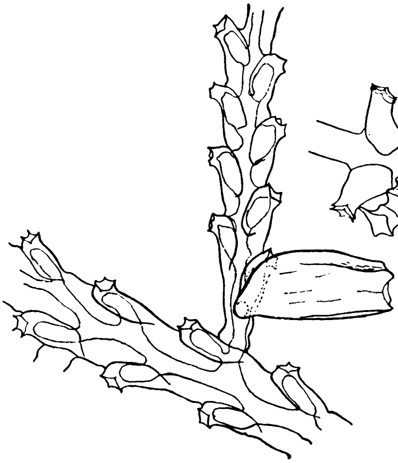
PLATE 4.



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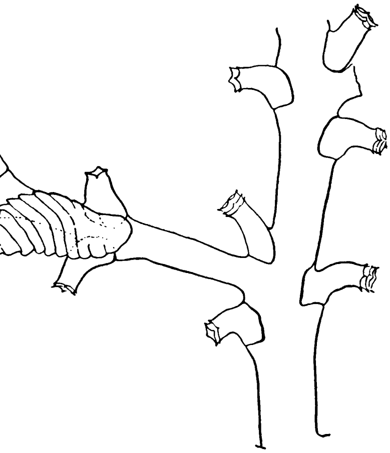

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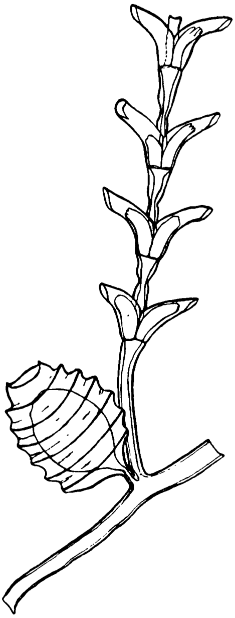

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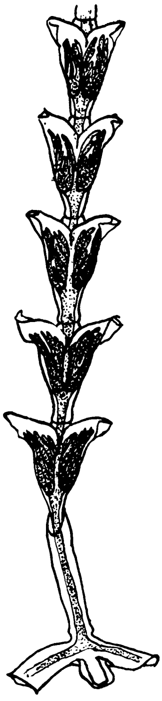

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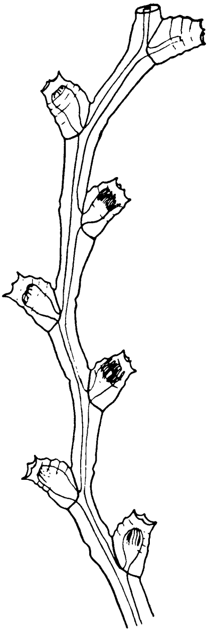

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PLATE 5.

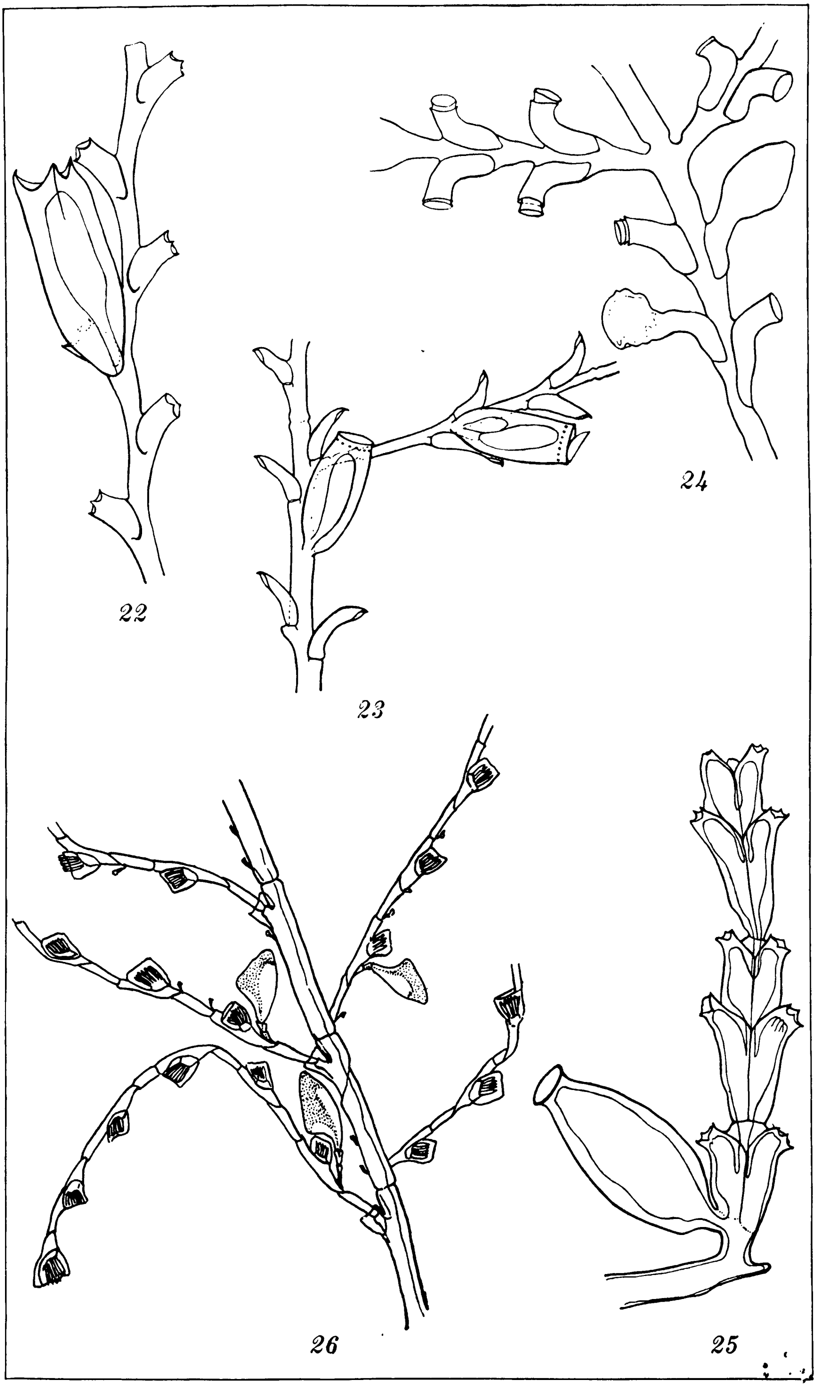

PLATE 6.

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THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 24 MAY, 1924 No. 5

NEW MALAYAN SPECIES OF OLIARUS STÅL (CIXIIDÆ, HOMOPTERA)

By F. MUIR

Of the Hawaiian Sugar Planters' Experiment Station, Honolulu, T. H.

TWO PLATES

The genus *Oliarus* Stål was erected by Stål in 1862, and eight species were placed in it at that time. Since then about one hundred forty species have been included in the genus, and it is now the largest in the family. The present paper adds twenty-three new species. It is strange that several species taken by Wallace in some of the localities from which these specimens came are not among the material; but, after a study of the descriptions by Walker and an examination of such types as are in the British Museum and the Stockholm Museum, I have concluded that the following are undescribed, with one exception.

All of the species dealt with in this paper are typical of the genus. They all possess the median ocellus, and the claval vein ends in the commissure and in no case in the apex or suture of the clavus. The vertex is quadrate with the apex slightly curved (Plate 1, fig. 2*b*), the width of different proportions; in some the width is equal to the length, in others it is considerably less. It is generally widest at the base, but in a few cases it is widest at the apex. There are useful characters in the vertex, but these must be used with discretion, since it shrinks in drying at times, especially in immature specimens. The genus *Urvillea* Kirkaldy represents an extreme, narrow form of vertex, but I cannot recognize this as of generic value, as every degree between it and the broad form is found. A transverse carina divides the vertex from the frons, but it is obscure in a few forms. From each lateral margin arises a carina which proceeds forward; the two converge and meet in the middle at the apex where they join the transverse carina. Thus two small areas are cut off and I shall call them the areolets (Plate 1, fig. 2*b*, *ar*). Their shape and size depend upon the point at which the converging carinæ arise; when they arise near the apex the areolets are short, and when they leave in the middle or beyond they are long and narrow. In a few cases the converging carinæ unite before the apex and join together before uniting with the transverse carina, thus making the areolets four-sided. In a few cases the single partition between the areolets becomes obsolete, leaving an angular transverse carina. In certain other forms, which I shall deal with at a later date as a genus distinct from *Oliarus*, there are no converging carinæ but only a single straight carina (apart from the apical transverse carina) across the vertex. A small ridge or carina is sometimes present on the medio-longitudinal basal portion. The frons and clypeus are in one plane, the carinæ of the former continuing on to the latter without a break (Plate 1, fig. 2). The sides are curved and the margins form deep carinæ or keels which are deepest in the middle. The clypeal suture (Plate 1, fig. 2*a*, *cs*) which divides the frons from the clypeus is deeply curved, forming a large emargination in the middle of the apex of the frons; this suture is often obscure. The median frontal carina has a small fork at its base and often has a slight break where the median ocellus is situated near the apex. About on a level with the median ocellus on each side there is an oval, translucent area, the fenestra (Plate 1, fig. 2*a*, *fen*), just in front of the antennæ. In an allied genus Distant has described these areas as ocelli, but this is an error. The labium is long, often extending to the apex of the abdomen; the apical segment is always very much longer than wide. The hind legs are strong with two or three strong spines apart from the apical ones. The pronotum is short in the middle, with the hind margin strongly angularly emarginate; the lateral carinæ arise in the middle, run along the hind margin for some distance, sometimes contiguous with it, and curve forward and end in the margin behind the eye, practically following the hind margin of the eyes. The mesonotum has five carinæ, the two inner lateral ones sometimes being obscure. The tegmina are hyaline, generally clear or with fuscous marks, more rarely colored over the greater portion. The costa coincides with the costal margin, the subcosta and radius are joined together into a stalk, the length of which varies in different species. Mf is slightly before the stigma, the cross veins being near the fork. M_1 and M_2 fork near to mf, M_3 and M_4 forking some considerable way from it; M_{1a} is generally present. Cu_1 forks some way before the apex of clavus but the position varies in different species; Cu_{1a} is always present; Cu_2 forms the claval suture. There are five or six apical cross veins which are not contiguous. The chief difference between *Oliarus* Stål and *Mnemosyne* Stål appears to be that in the latter M_1 and M_2 fork far away from mf and M_3 and M_4 close to mf and there is a M_{4a}. This can be expressed by saying that M_2 had passed over to M_{4a}. The body is considerably flattened horizontally and the tegmina are nearly flat or very obtusely tectiform and the hind margins do not overlap beyond the clavus. The pygofer of the female forms a flat, oval plate, considerably wider than long, the length being measured from the base of the anal segment to the base of the ovipositor; it forms a large surface for the secretion of the wax filaments characteristic of this and some other genera of the family. The anal segment is flat and comparatively thin; its size varies in different species but it is generally fairly or very large, forming a thin disk with rounded sides; the anus is at the apex. The genital styles form an incomplete ovipositor; they are narrow, flat, and pointed, and not coadapted as they are in the complete ovipositor. The seventh abdominal sternite is the pregenital plate, and the shape of the posterior margin offers good specific differences in most species. The male genitalia are of the usual cixiine type. The ædeagus consists of a basal portion, the periandrium, which is mostly tubular or subtubular but sometimes flattened and often bears spines and other processes; the distal portion is the penis and generally consists of a membranous appendage, on which the opening of the ejaculatory duct is situated, as well as one or more spines. It is sometimes difficult to say whether certain spines pertain to the penis or to the apex of the periandrium. The complexity to which the ædeagus often attains is astonishing, and one wonders how it can perform its function with large spines pointing in different directions. Running the length of the periandrium is a chitinous tube, the apodeme of the penis, its base being attached to the apodemes of the genital styles. The ejaculatory duct passes through this apodeme (it may be a strongly chitinized portion of this duct) and continues to the orifice of the penis.

While the chrootic characters are very weak for systematic purposes the genitalia, more especially the ædeagus, are the reverse; for here the difficulty lies in trying to find a relationship between species instead of a difference. It is, therefore, to be regretted that workers have hitherto ignored these organs and confined their descriptions to chrootic characters, mainly to color, and so have produced a set of descriptions which are mainly paraphrases of one another.

Species of this genus are known to live on some economic plants and, although they are seldom if ever numerous enough to do damage, they should not be ignored as they may prove to be vectors of some of the obscure plant diseases.

The types of the species described below have been deposited in the collection of the Hawaiian Sugar Planters' Experiment Station and bear the type numbers of that institution; paratypes when present have been placed in the Baker collection. Measurements are from the apex of head to anus and from the base to apex of one tegmen.

Oliarus hyalinipennis sp. nov. Plate 1, fig. 1.

Male.—Length, 5.5 millimeters; tegmen, 7. Length of vertex equal to width at base; areolets very short, reaching about one-fourth from apex or less. Cu fork slightly basad of Sc + R. Pygofer in ventral view fairly long, medioventral process angular, lateral margins angularly produced; genital styles not produced beyond the margins of pygofer; anal segment fairly long, projecting well beyond pygofer, length about twice the width, apex truncate. Ædeagus fairly simple, periandrium long, narrow, with a small spine on right side about middle; the penis has a strong spine on left side, a shorter and broader one beside it, and a more complex structure partly membranous.

Black or very dark brown, a spot on each side of apex of frons; carinæ of pronotum, tegulæ and apices of femora and tibiæ lighter. Tegmina hyaline, veins dark brown, a light mark at node, ends of apical cells slightly fuscous, veins dark brown. Wings hyaline with dark brown veins, slightly fuscous along apical margin, granules minute, bearing black macrotrichia.

MINDANAO, Kolambugan (*Baker*), 1 male. Type No. 1074.

Oliarus lucidipes sp. nov. Plate 1, figs. 3*a* and 3*b*.

Male.—Length, 2.8 millimeters; tegmen, 3.6. Length of vertex about equal to width at base, areolets reaching back about one-fourth from apex, the division between them being obscure or obsolete, the resulting carina subangular. Cu forking basad of Sc + R. Lateral margins of pygofer slightly arcuate; medioventral process narrow, sublanceolate; anal segment projecting considerably beyond pygofer, its length one and one-fourth the width, apex slightly angularly emarginate; genital styles fairly long, reaching well beyond the pygofer nearly to apex of anal segment, apex rounded. Periandrium fairly small, on the right side produced into a longitudinal ridge, penis with three spines curving to the left, a small round plate at apex and a membranous process. In specimens from Penang Island the flange on the periandrium is larger and more roundly curved on its outer margin.

Dark brown, carinæ of head and pronotum considerably lighter, carinæ of mesonotum slightly lighter; coxæ and femora brown, tibiæ and tarsi whitish; abdomen brown with the hind margins of segments light. Tegmina hyaline, fuscous over the apical half, veins yellowish with minute darker granules, bearing small macrotrichia.

Female.—Length, 3 millimeters; tegmen, 4. In color and general build similar to male. Pygofer much wider than long, suboval; hind margin of pregenital plate slightly sinuate; genital styles not quite as long as pygofer; anal segment small, about half the length of pygofer and about as long as wide.

PENANG, 3 males and 1 female type (*Baker 10058*). BASILAN, 1 male (*Baker 1315*). MINDANAO, Dapitan, 1 male. LUZON, Mount Maquiling, 2 males (*Baker 10067*); Los Baños, 2 males (*Muir*), October, 1915. Type No. 1075.

Oliarus fuscipennis sp. nov.

Female.—Length, 3.4 millimeters; tegmen, 5.2. Length of vertex equal to width; areolets reaching to middle of vertex. Cu fork slightly basad of Sc + R. Pygofer large, anal segment comparatively small, about one-third as wide and about two-thirds the length of pygofer, widest at base, gradually narrowed to apex, sides slightly curved; genital styles not as long as pygofer, narrow; hind margin of pregenital plate truncate.

Dark brown, carinæ of head and thorax lighter, tegulæ, legs, and abdomen light. Tegmina hyaline suffused with a brownish infuscation; veins light; granules minute, numerous. Wings hyaline, fuscous, with dark veins. Stigma light with a dark mark along inner margin.

EAST JAVA (*Muir*), April, 1914, 1 female. Type No. 1076.

Oliarus flavipes sp. nov. Plate 1, figs. 4*a* and 4*b*.

Male.—Length, 4.5 millimeters; tegmen, 5.2. Length of vertex 1.5 times the width at base, narrowest in middle, widest at base; areolets reaching about one-third from apex, the dividing carina between them obsolete. The Cu fork slightly basad of the Sc + R fork.

In color this species is similar to *O. lucidipes;* in the genitalia it differs in the ædeagus. The ridge on the right side of the periandrium is pointed and there is a fourth spine which is attached to the membranous process.

Female.—Length, 3.6 millimeters; tegmen, 5. The vertex not narrowed across the middle as in the male and the length is equal to the width, but I place it with this species. Anal segment about one-half the length of pygofer and one-eighth the width, sides subparallel, apex truncate; genital style not quite as long as pygofer; hind margin of pregenital plate straight or very slightly curved in middle.

Lighter in color than the male; veins not darker beyond cross veins, granules minute, numerous, bearing light macrotrichia.

LUZON, Mount Maquiling (*Baker 9358*), 1 male (type) and 4 females; Los Baños (*Baker and Muir*), 2 females. This female is closely related to the female of *O. lucidipes* and if it is not the spouse of this species it is closely related to it. Type No. 1077.

Oliarus granulatus sp. nov. Plate 1, figs. 5*a* and 5*b*.

Male.—Length, 4 millimeters; tegmen, 5. Vertex slightly longer than wide (1 to 1.2), widest at base which is angularly emarginate; a fine carina runs from middle to base; areolets short, reaching about one-fourth from apex. Forking of Cu and Sc + R about level. Pygofer in ventral view broad and short, medioventral process sublanceolate, apex rounded, lateral margins slightly asymmetrical, angularly produced, the left side more acutely than the right; anal segment large, broader than long, the apex broad and subtruncate. Ædeagus complex; from the base of the periandrium arise two large processes, the one on the right with an acute apex turned at right angle to body of process; a second spine arises about the middle, the process on left shaped somewhat like a hatchet, with a large spine at the back; from the apical portion, or penis, arise two long, curved spines and a semimembranous process.

Dark brown, carinæ of head and thorax lighter; legs, sterna of abdomen, and pygofer light brown. Tegmina hyaline, veins light brown or yellow with numerous minute granules slightly darker than the veins, apices of apical vein and the cross veins slightly fuscous. Wings hyaline with brown veins.

Female.—Length, 3.2 millimeters; tegmen, 5.6. In color similar to male. Pygofer wider than long; anal segment comparatively small, smaller than pygofer, wider than long; genital styles about as long as pygofer.

LUZON, Bataan Province, Mount Limay, 1 male (holotype): Laguna Province, Mount Maquiling (*Baker*), 1 female; Los Baños (*Muir*), 1 male and 1 female. Type No. 1078.

Oliarus geniculatus Stål.

This species is represented in the Stockholm Museum by one female, the type. It is very close to *O. longulus*, but the emargination in the middle of the hind margin of the subgenital plate is not so deep and the color of the veins of the tegmina is different. It is best to keep the two species separate until further material can be studied. It is not represented in Baker's collection or my own.

Oliarus longulus sp. nov. Plate 1, figs. 6*a*, 6*b*, and 6*c*.

Male.—Length, 7 millimeters; tegmen, 8. Length of vertex 1.3 times the width at base which is deeply and angularly emarginate, a fine carina running from base to about middle, areolets small, reaching about one-fourth from apex. Forking of Sc + R and Cu about level.

Lateral margins of pygofer projecting considerably with the apex truncate, medioventral process angular and fairly narrow; anal segment large, length more than twice the width, sides arcuate, apex produced into a broad point which is curved ventrad, anus near apex; genital styles comparatively small, with a short, wide hook at the apex. The periandrium is fairly well chitinized with a large, flat, widely diverging furcation on the side, and a large, curved spine on the other side nearer the apex; the penis consists of a membranous funnel and three large spines, two arising on one side of the funnel which are as long as the ædeagus and slender; the third arises on the other side and is thicker and shorter.

Dark brown or black, the carinæ of pronotum lighter, the carinæ of head very slightly lighter, two small, light marks on clypeal suture; legs and tegulæ lighter. Tegmina hyaline, clear or slightly white and opaque, veins dark brown with minute granules bearing small black macrotrichia, stigma brown, apex bordered with fuscous from stigma to apex of clavus. Wings hyaline, slightly opaque, veins brown, apex narrowly bordered with light fuscous.

Female.—Length, 8 millimeters; tegmen, 9.5. The female differs in color from the male in having the tegmina hyaline slightly tinged with yellow, the veins are dark brown with lighter marks upon them, the mark in the clavus is plainer and extends as an obscure mark to fork of Sc + R, the infuscation on apical margin and apical cross veins is broader and darker, but it varies in the three female specimens. The pygofer is large, much wider than long; the anal segment large, thin, as wide as pygofer and slightly longer, oval; genital styles as long as pygofer; the pregenital plate is produced from sides to middle where it is produced into two processes near together, with rounded apices.

MINDANAO, Butuan (*Baker 10043, 17523, 17524*), 1 male and 3 females. Type No. 1079.

Oliarus prolongulus sp. nov.

Female.—In size, build, and color this species is similar to *O. longulus*, but the hind margin of the pregenital plate is truncate and without any processes. That the male will show distinct differences I feel quite sure.

BASILAN (*Baker*), 1 female. Type No. 1080.

Oliarus longicauda sp. nov. Plate 1, figs. *7a* and *7b*.

Male.—Length, 6.5 millimeters; tegmen, 7. Length of vertex 1.3 times the width at base, widest at base which is deeply and angularly emarginate; a slight carina runs from middle of base to about middle; areolets small, reaching about one-fourth from apex. Forking of Sc + R and Cu about level. Pygofer and anal segment long and narrow, in shape similar to those in *O. longulus*. The ædeagus is quite distinct, the periandrium has a small, bifurcate plate on left side, a small curved spine on right, and a large, strong spine at apex pointing distad; the penis or apical portion of the ædeagus consists of two very long, slender spines and one shorter and stouter spine as well as the membranous portion.

Dark brown or black; the carinæ of head and pronotum lighter and two small light marks on frons at frontoclypeal suture; legs light brown, lighter at apices of femora and tibiæ. Tegmina hyaline, slightly opaque and white, veins dark brown with minute granules; stigma dark brown and a margin of fuscous from stigma to apex of clavus. Wings hyaline, slightly whitely opaque, veins dark brown, a slight apical margin of fuscous.

Female.—Length, 8 millimeters; tegmen, 9. The female I associate with this species differs in having the tegmina and wings hyaline slightly tinged with yellow and the veins brown with lighter marks; besides the apical infuscation there is infuscation on the apical cross veins, a small dark spot in clavus slightly beyond the fork of claval veins.

Pygofer large, wider than long, oval, genital styles as long as pygofer; anal segment very large, as wide as pygofer and slightly longer, base narrow. Hind margin of pregenital plate slightly produced from sides to middle where it is produced into two small lobes.

MINDANAO, Surigao (*Baker*), 1 male and 1 female. This species was confused with *O. longulus* until an examination of the ædeagus demonstrated their distinctness. Type No. 1081.

Oliarus walkeri (Stål). Plate 1, figs. 8*a*, 8*b*, and 8*c*.

Cixius walkeri STÅL Freg. Eug. Resa, Ins. (1859) 149, 272.

Male.—Length, 4.2 millimeters; tegmen, 5. Length of vertex about 1.3 times the width at base; areolets long, reaching one-half to two-thirds from apex; the short median carina distinct; base slightly wider than apex. The forking of Cu basad of that of Sc + R. Anal segment slightly longer than wide, sides arcuate, apex slightly emarginate or truncate; lateral margins of pygofer slightly asymmetrical, the right side roundly produced, the left side more squarely. In specimens from Basilan there is a small notch along the upper side of the produced portion near the apex which is missing from specimens from other localities. Genital styles fairly narrow, the apex rounded, produced into a short, thick, curved hook on outer side. Periandrium thin, tubular, simple; the penis consists of two thin curved spines and a membranous process.

Dark brown; carinæ of head and pronotum yellow or light brown, legs light brown. Tegmina hyaline, veins basad of cross veins yellow, apical of cross veins brown, stigma light brown with a dark inner edge, granules very small and obscure, same color as veins. Wings hyaline with light brown veins.

Female.—Length, 4.8 millimeters; tegmen, 5.7. In general build and color the female is similar to the male. Anal segment slightly longer than wide, about as long as pygofer and about half the width, broadest near base and gradually narrowing to apex; genital styles nearly as long as pygofer, narrow; hind margin of pregenital plate slightly produced on middle fifth and slightly emarginate in the middle.

BASILAN (*Baker 13345*), 1 male and 1 female. MINDANAO, Surigao, 1 female: Dapitan (*Baker 1316*), 2 females. PALAWAN, Puerto Princesa (*10046, 10048 Baker*), 2 females. SINGAPORE (*10057, 10051, 10049 Baker*), 2 males and 1 female. PENANG (*10053, 10044, 10045 Baker*), 2 males and 6 females. BORNEO, Sandakan, 1 male.

There are some slight differences in both sexes from these localities, but none appears to be sufficient to divide them into two or more species.

The type material in the Stockholm Museum consists of two specimens from Manila, a female, the type, and a specimen without an abdomen, and one male from Malacca. I was not able to examine the genitalia of this specimen to see if it was the same species. There is also one specimen collected by Semper, which cannot belong to the type material.

Oliarus dispar sp. nov. Plate 1, figs. 9*a* and 9*b*.

Male.—Length, 4 millimeters; tegmen, 4.3. Length of vertex 1.4 times the width at base; areolets long, reaching about halfway to base. Cu forking basad of Sc+R. Lateral margins of pygofer asymmetrical, the right side produced into a long, thin spine, the left obtuse; length of anal segment 1.4 times the width, subovate, widest about one-third from base. Ædeagus complex, the periandrium with three spines, a small one near base, a longer, curved one about middle, and another from apex; the penis complex with a flat, curved disk at base which is produced into a curved spine; the penis is flat, chitinous on basal half, and membranous beyond with two spines near middle. The flat disk may form part of the periandrium and not the penis. Genital styles with a flattened crook at apex.

Brown, the carinæ of head and thorax lighter; legs light. Tegmina hyaline with light brown veins, slightly fuscous at ends of apical veins and on apical cross veins; granules minute, sparse, same color as veins before the cross veins, slightly fuscous apical of cross veins. Wings hyaline with light brown veins.

Female.—Length, 4.6 millimeters; tegmen, 5.2. In color similar to the male. Pygofer short, broad; anal segment about half as broad as pygofer, base wide, gradually narrowing to apex, about as long as pygofer. Genital styles about as long as pygofer. Hind margin of pregenital segment sinuate, the middle half being slightly produced.

JAVA, Pekalongan (*Muir*), 1907, 2 males and 1 female. Type No. 1082.

Oliarus proprius sp. nov. Plate 2, figs. 10*a* and 10*b*.

Male.—Length, 4.4 millimeters; tegmen, 5. Length of vertex about double the width at base; areolets long, narrow, reaching about half the length from apex. Cu forking slightly basad of Sc + R. Lateral margins of pygofer slightly asymmetrical, the left side being produced slightly more than the right, in ventral view pygofer not very long, slightly compressed across middle. Length of anal segment one and one-third times the width, sides arcuate, the apical corners acute and turned under and overlapping. Genital styles long, the apex acute, inner margin convex on apical half, straight on basal half, outer margin concave on apical third where the style is widest, with another concavity on basal two-thirds. The periandrium has three spines: A long, curved spine from near the base on the ventral aspect, a long curved spine from the apical portion on left, and a smaller one on right; the penis is semimembranous with a small spine on the middle and another at the apex.

Dark brown; carinæ of head and pronotum lighter; legs light brown. Tegmina hyaline, slightly yellowish, veins light yellow, slightly brown on apical veins, apical cross veins slightly fuscous, granules minute, sparse, same color as veins. Wings hyaline with brown veins.

JAVA, Buitenzorg (*Muir*), 1 male. Type No. 1083.

Oliarus maculipennis sp. nov. Plate 2, fig. 11.

Male.—Length, 4 millimeters; tegmen, 4.2. Length of vertex about twice the width; areolets narrow reaching back to about the middle. Cu fork slightly basad of Sc + R fork. Pygofer short and broad, sides roundly produced; anal segment slightly longer than broad, sides arcuate, apex narrowly truncate; genital styles small with a short curve at apex; ædeagus simple, the periandrium long, narrow, tubular, without armature, the apical portion membranous; the penis has two fairly strong, curved spines and a membranous appendage.

Vertex, frons, genæ, pronotum, tegulæ, and legs light brown, clypeus and labium dark brown, a small dark mark at base of frons and on genæ, mesonotum dark brown, lighter on median portion, abdomen light brown with darker marks in middle. Tegmina hyaline with light veins, costa with a series of light and dark marks, granules irregular, sparse, dark brown, bearing black hairs; these give the tegmina an irregular spotted appearance. Wings hyaline with brown veins.

Timor Laut Islands, Larat Island (*Muir*), December, 1907, 1 male. Type No. 1084.

Oliarus brunnifrons sp. nov.

Female.—Length, 6.5 millimeters; tegmen, 7.3. Length of vertex double the width at base; areolets short, reaching one-fifth from apex, four-sided. Cu forking considerably distad of Sc + R fork. Anal segment large, longer than pygofer and about as wide as pygofer, sides rounded; genital styles about as long as pygofer; hind margin of pygofer sinuate, the median portion slightly concave. Head brown, the carinæ darker, the median ocellus yellow; pronotum light; mesonotum dark brown; legs, abdomen, and pygofer brown. Tegmina hyaline; veins brown, Sc beyond fork, the suture, Cu beyond fork, and middle of claval veins lighter; stigma narrow, light; apical cross veins fuscous spreading into membrane, a small fuscous mark on apical radial and two on apical median cells, a dark mark at apex of clavus. Wings hyaline, slightly fuscous, veins brown.

SINGAPORE (*Baker*), 1 female. Type No. 1085.

Oliarus proimpeditus sp. nov. Plate 2, figs. 12*a* and 12*b*.

Male.—Length, 3.8 millimeters; tegmen, 4.3. Length of vertex about 1.5 times the width at base; areolets reaching to about middle or slightly beyond. Cu forking considerably nearer the base than Sc + R. In ventral view pygofer long, the lateral margins produced into two subacute, angular processes, the medioventral process long, apex acute. Length of anal segment slightly greater than width, narrowest at base, sides arcuate, apex produced into two rounded lobes which are turned ventrad. Genital styles slender, the apex in shape somewhat like the head of a bird with a thick bill. Ædeagus complex; from the left ventrobasal margin of the periandrium arises a long, flat spinelike process with a pointed apex, the outer margin being membranous; between the outer basal angle of the process and the middle of the left edge of the periandrium there is an angular membranous process, apical of this the periandrium narrows considerably; the penis gives rise to three chitinous spines and a membranous process. Head and thorax dark brown or black, carinæ lighter brown; coxæ, femora, and abdomen dark brown, tibiæ and tarsi light. Tegmina hyaline, veins basad of cross veins light brown, veins apical of cross veins darker, granules small, sparse, same color as veins. Wings hyaline with brown veins.

LUZON, Benguet Subprovince, Baguio (*Baker*), 1 male. Type No. 1087.

Oliarus impeditus sp. nov. Plate 2, figs. 13*a* and 13*b*.

Male.—Length, 3.4 millimeters, tegmen, 3.6. Length of vertex nearly twice (1.8) the width at base, the areolets reaching to about the middle. Cu forking considerably nearer the base than Sc + R. The lateral margins of the pygofer produced into a pair of pointed processes. Anal segment slightly longer than wide, narrowest at base, sides arcuate; the apex is slightly asymmetrical, angular, and turned under. Genital styles fairly slender, the apex like the head of a bird with a thick, curved beak. Ædeagus complex; the periandrium is broad and flat, the left side is produced into a large, flat process, five or six times longer than wide, with an acute apex; from the middle of the ventral apical margin arises a long, curved, flat, spinelike process, narrowest in middle, with acute apex; five processes arise from the penis, a long, slender curved one with a small one at the base and three smaller ones on the dorsal side.

Head and thorax dark brown or black with the carinæ lighter brown; coxæ and abdomen dark brown, femora, tibiæ, and tarsi light. Tegmina hyaline, veins basad of cross veins light brown, apical of cross veins darker brown, granules small, sparse, same color as veins. Wings hyaline with brown veins.

Female.—In general build and color similar to male. Anal segment about as long as pygofer and one-half as wide, sides rounded, widest near base; genital styles narrow, as long as pygofer; hind margin of pregenital plate truncate.

MINDANAO, Dapitan, (*Baker 10047, 13346*), 2 males and 1 female. Type No. 1087.

Oliarus singularis sp. nov. Plate 2, fig. 14.

Female.—Length, 5.2 millimeters; tegmen, 5.7. Length of vertex 1.7 times the width. Forks of Sc + R and Cu about level or Cu slightly basad. Anal segment two-thirds the width of pygofer, about as long, widest near base, gradually narrowing to apex, sides arcuate; genital styles as long as pygofer, narrow; posterior margin of pregenital plate produced into two acute spines about one-third from the lateral margin, the space between them being roundly emarginate. Head and pronotum light brown, dark in middle of frons, legs light brown, mesonotum dark brown, abdomen lighter brown. Tegmina hyaline with brown veins, granules minute, same color as veins. Wings hyaline with brown veins.

JAVA, Roban (*Muir*), 1 female. Type No. 1088.

Oliarus bakeri sp. nov.

Female.—Length, 5.3 millimeters; tegmen, 6.3. Length of vertex 2.5 times the width at base; areolets long and very narrow, reaching about halfway to base; mediolongitudinal carina very short, obscure. The Cu fork considerably nearer base than that of Sc + R. Hind margin of pregenital plate nearly straight, a very small, shallow emargination in middle with the corners of the emargination very slightly produced; pygofer oval, one-third wider than long; anal segment about as long as pygofer and about half the width, oval; genital styles not quite as long as pygofer.

Head, pronotum, tibiæ, tarsi, and tegulæ light brown, slightly darker on face between carinæ, apex of clypeus dark; mesonotum dark brown or black; coxæ, femora, and abdomen dark brown, margins of abdominal segments light. Tegmina hyaline, shiny, dark brown with a white subcrescent-shaped mark on costa extending from about one-third from base of costa to the stigma and reaching back to the basal portion of R beyond the fork; veins same color as membrane but darker, granules numerous, minute, bearing small, black macrotrichia. Wings brown with darker veins, a small white mark on middle of costa.

BORNEO, Sandakan (*Baker*), 1 female. This species is very distinctly colored. Type No. 1089.

Oliarus pallidifrons sp. nov. Plate 2, fig. 15.

Male.—Length, 5.2 millimeters; tegmen, 5.5. Length of vertex 2.6 times the width; base angularly emarginate, apex slightly curved, areolets small reaching about one-fourth from apex. Cu forking considerably before Sc + R. Length of anal segment about double the width, sides arcuate, apex truncate, anus at apex; lateral margins of pygofer angularly produced with the apex curved slightly upward, medioventral process small, rounded; genital sytles in flat view curved at apex with the inner corner produced into a small process, the outer corner angular, a small triangular process on the inner surface. Ædeagus complex without any good demarcation between periandrium and penis; there is one broad process whose apex is produced into two curved spines, one strong, long spine as long as the ædeagus, a small spine near base, and another about half the length of the ædeagus.

Vertex and mesonotum dark brown or nearly black, pronotum, frons, and clypeus lighter, coxæ and pleura of thorax dark brown, legs light brown. Tegmina hyaline, slightly tinged with yellow, veins basad of cross veins yellow or light brown, distad of cross veins dark brown; slightly fuscous at apex of clavus and over apical cross veins; granules very small, bearing small, black macrotrichia.

LUZON, Los Baños (*Muir*), September, 1915, 2 males. Type No. 1090.

Oliarus bilineatus sp. nov. Plate 2, figs. 16*a* and 16*b*.

Male.—Length, 4 millimeters; tegmen, 5. Length of vertex about three and one-half times the width, slightly wider at apex than at base, base deeply and angularly emarginate, apex projecting slightly in front of eyes, slightly curved, areolets narrow, reaching about one-third from apex. Cu fork slightly basad of Sc + R fork.

Width of anal segment about two-thirds the length, the lateral margins curved down at apex where they meet in the middle line; medioventral process of pygofer lanceolate with a thick base, sides of pygofer slightly curved with a small angular projection at anal angle. Genital styles in ventral view reaching beyond pygofer, apices curved, widest on basal half. Ædeagus fairly large, periandrium moderately short and broad with a large, rounded projection on side on basal half, a strong, curved spine on the left side near apex and another on right side; the penis mostly membranous with two large, curved spines at the apex.

Castaneous; carinæ of head and thorax lighter, lighter between the lateral carinæ of mesonotum forming two light lines down the thorax; legs lighter. Tegmina hyaline, very slightly tinged with yellow; veins yellow or light brown; the claval margin, cross veins, apical cross veins and apical veins darker; granules same color as veins, sparse, bearing black macrotrichia.

There is a very slight infuscation on the apical margins of the apical cells. Wings hyaline, veins brown, a slight infuscation on the apical margin.

Female.—Length, 4.3 millimeters; tegmen, 5.3. In build and color similar to male. Pygofer much wider than long; anal segment as long as pygofer, not quite so wide, sides rounded; genital styles about as long as pygofer; hind margin of pregenital plate straight.

Timor Laut Islands, Larat Island (*Muir*), 1907, 1 male and 2 females. Type No. 1091.

Oliarus acuminatus sp. nov. Plate 2, figs. 17*a* and 17*b*.

Male.—Length, 3.7 millimeters; tegmen, 4.5. Length of vertex three times the width, areolets long and narrow, reaching two-thirds from apex. Forking of Cu slightly basad of Sc + R. Pygofer in ventral view wide, flat, and short, medioventral process acute; anal segment longer than wide (1.3 to 1), sides arcuate, apex acute, turned ventrad and slightly under, when at rest genital styles reaching the turned-down apex of anal segment; periandrium long and thin without any processes, the penis consisting of four spines and a membranous process which are best understood by a study of the figure.

Head and pronotum light brown, the apex of clypeus dark, the lateral carinæ of frons sometimes tinged with green, mesonotum darker brown, lighter between the outer carinæ, legs light brown. Tegmina hyaline with brown veins which are darker apical of cross veins, granules minute, numerous, bearing small brown macrotrichia; stigma brown, slightly fuscous over apical cross veins, apical veins slightly thickened.

Female.—Length, 4 millimeters; tegmen, 5.3. In build and color similar to male. Pygofer wider than long, anal segment much narrower than pygofer, oval; genital styles about as long as pygofer; hind margin of pregenital plate truncate.

Timor Laut Islands, Larat Island (*Muir*), December, 1907, 3 males and 4 females. Type No. 1092.

Oliarus albomaculata sp. nov.

Female.—Length, 7 millimeters; tegmen, 8. Length of face three times the width at apex, widest at apex; areolets long and narrow, reaching about to middle. Forking of Cu and Sc + R about level. Pygofer wider than long, anal segment as long as pygofer, broadest at basal third where it is about half the width of pygofer, gradually narrowing to apex; hind margin of pregenital plate angularly produced in the middle, the apex of the produced part having a minute indentation; genital styles much longer than the pygofer.

Head, thorax, and abdomen brown, frons slightly darker than clypeus, a white or yellowish white mark from fenestra to the clypeal suture and touching the lateral margin; mesonotum darker over the median carina and on lateral portions; legs light brown. Tegmina hyaline; Sc + R stalk, subcosta to stigma, Cu beyond fork, and suture yellow, R, M to cross veins and Cu to cross veins dark brown, apical veins brownish, base and apex of clavus, cross and apical cross veins fuscous. Wings hyaline, veins brown.

LUZON, Los Baños (*Muir*), September, 1915, 1 female (holotype); Mount Maquiling (*Baker 9355, 9356*), 4 females. In one specimen the infuscation at apex of clavus extends as a faint band to costa. This species is near to *O. borneensis* so far as the females are concerned. Type No. 1093.

Oliarus borneensis sp. nov. Plate 2, fig. 18.

Male.—Length, 6 millimeters; tegmen, 6.4. Length of vertex slightly more than twice the width at base; areolets long and narrow, reaching halfway from apex. Forking of Cu and Sc + R level. The right lateral margin of pygofer more angularly produced than the left; length of anal segment 1.5 times the width, the apex truncate with middle of the margin produced into a small process turned ventrad, the apex of the process being slightly emarginate; genital styles small, the apex hatchet-shaped. Ædeagus with a simple periandrium; the penis bears two spines, one a long, slender one with a twist about one-third of apex, and the other forming a complete spiral around the membranous process.

Dark brown; carinæ of head and thorax and the legs lighter. Tegmina hyaline, veins brown, slightly infuscate over the apices of apical cells and over apical cross veins. Wings hyaline, veins brown.

Female.—Length, 4.8 millimeters; tegmen, 6.2. In color similar to male but the infuscation in apical cells slightly darker. Pygofer longer than broad, oval; anal segment as long as pygofer, longer than broad; genital styles as long as pygofer; pregenital plate with posterior margin truncate.

BORNEO, Sandakan (*Baker 10052*), 1 male and 1 female. There is one female from Surigao, Mindanao, which I place with this species, but not with the type series. Type No. 1094.

Oliarus exiguus sp. nov. Plate 2, fig. 19.

Male.—Length, 4.4 millimeters; tegmen, 5.4. Length of vertex 3.6 times the width; areolets long and narrow, reaching one-third or more from apex. Forking of Cu and Sc + R level. In ventral view pygofer fairly long, anal segment projecting about one-third beyond pygofer; lateral margins of pygofer produced bluntly, a little asymmetrical, the right being less truncate than the left; width of anal segment two-thirds the length, apex slightly angularly emarginate. The ædeagus is complex; the periandrium is fairly large with two large spines on the left side near base, the shorter one being broad; the penis has three spines, one very long, thin, and curved, the second not so long, and the third smaller.

Dark brown or black, carinæ of head and pronotum lighter, legs lighter brown, abdomen and genitalia dark brown with the hind margins of segments light. Tegmina hyaline, veins brown, granules minute, bearing small black macrotrichia, slightly fuscous over apical cross veins. Wings hyaline with brown veins.

SINGAPORE (*Baker 10055*), 2 males. Type No. 1095.

Oliarus laratensis sp. nov. Plate 2, figs. 20*a* and 20*b*.

Male.—Length, 6 millimeters; tegmen, 7. Length of vertex four times the width, base deeply and angularly emarginate; areolets very short, reaching about one-eighth to one-ninth from apex, nearly as broad as long. Cu forking considerably before Sc + R fork. In ventral view pygofer and anal segment fairly long, anal segment reaching a little beyond pygofer, genital styles nearly reaching apex of anal segment; length of anal segment about one and a half times the width, apex truncate; lateral margin of pygofer angularly produced; genital styles in flat view fairly narrow, inner margin slightly sinuous, angular at apex; from the inner surface near apex arises a long, slender spine. Periandrium small and simple, penis complex, consisting of a large, flat, subcrescent-shaped plate, a strong curved spine from near the base, and a complex semimembranous construction supported by chitinizations.

Vertex dark brown; frons, clypeus, pronotum, and legs light brown or yellow, mesonotum dark brown, lighter between outer carinæ. Tegmina hyaline, very slightly opaquely white, veins dark brown, lighter in middle of Sc + R stalk and on apical portion of claval margin, granules minute and numerous, bearing small, black macrotrichia, stigma brown, a small fuscous mark on apical R, M_1 and Cu_{1a} also slightly over apical cross veins. Wings hyaline, veins brown, narrowly and slightly fuscous along apical margin.

Female.—Length, 6 millimeters; tegmen, 7.3. In general build and color similar to male. Pygofer much wider than long, oval; anal segment at base as broad as pygofer narrowing to apex, slightly longer than pygofer, genital styles slightly longer than pygofer, broad at base, anterior styles nearly as long as posterior; hind margin of pregenital plate slightly and roundly produced in middle.

Timor Laut Islands, Larat Island (*Muir*), December, 1907, 4 males and 6 females. Type No. 1096.

ILLUSTRATIONS

PLATE 1

FIG. 1. *Oliarus hyalinipennis* sp. nov.; male genitalia, left lateral view, × 25.

2. *Oliarus* sp.; *a*, frons and clypeus, front view; *fen*, fenestra; *cs*, clypeal suture; *b*, vertex; *ar*, areolet.

3. *Oliarus lucidipes* sp. nov.; *a*, male genitalia, ventral view; *b*, ædeagus, left lateral view, × 25.

4. *Oliarus flavipes* sp. nov.; *a*, male genitalia, left lateral view; *b*, ventral view, × 25.

5. *Oliarus granulatus* sp. nov.; *a*, male genitalia, ventral view; *b*, ædeagus, ventral view, × 25.

6. *Oliarus longulus* sp. nov.; *a*, male genitalia with ædeagus dissected away, right lateral view, × 12; *b*, ædeagus, left lateral view, × 25; *c*, female pregenital plate, posterior margin, × 12.

7. *Oliarus longicauda* sp. nov.; *a*, male genitalia, ventral view, × 12; *b*, female pregenital plate, posterior margin, ×12.

8. *Oliarus walkeri* (Stål); *a*, male genitalia, left lateral view, × 25; *b*, apex of ædeagus, ventral view; *c*, female pregenital plate, posterior margin.

9. *Oliarus dispar* sp. nov.; *a*, male genitalia, ventral view, × 25; *b*, ædeagus, ventral view.

PLATE 2

FIG. 10. *Oliarus proprius* sp. nov.; *a*, male genitalia, ventral view, × 25; *b*, ædeagus, ventral view, × 25.

11. *Oliarus maculipennis* sp. nov.; ædeagus, right lateral view, × 50.

12. *Oliarus proimpeditus* sp. nov.; *a*, male genitalia, ventral view, × 25; *b*, ædeagus, ventral view.

13. *Oliarus impeditus* sp. nov.; *a*, male genitalia, ventral view, × 25; *b*, ædeagus, ventral view, × 50.

14. *Oliarus singularis* sp. nov.; female pregenital plate, posterior margin.

15. *Oliarus pallidifrons* sp. nov.; male genitalia, right lateral view, × 25.

16. *Oliarus bilineatus* sp. nov.; *a*, male genitalia, left lateral view, × 25; *b*, ventral view, × 25.

17. *Oliarus acuminatus* sp. nov.; *a*, male genitalia, ventral view, × 50; *b*, ædeagus, left lateral view, × 50.

18. *Oliarus borneensis* sp. nov.; male genitalia, left lateral view, × 25.

19. *Oliarus exiguus* sp. nov.; male genitalia, left lateral view, × 25.

20. *Oliarus laratensis* sp. nov.; *a*, male genitalia with ædeagus dissected out, left lateral view, × 25; *b*, ædeagus, left lateral view, × 25.

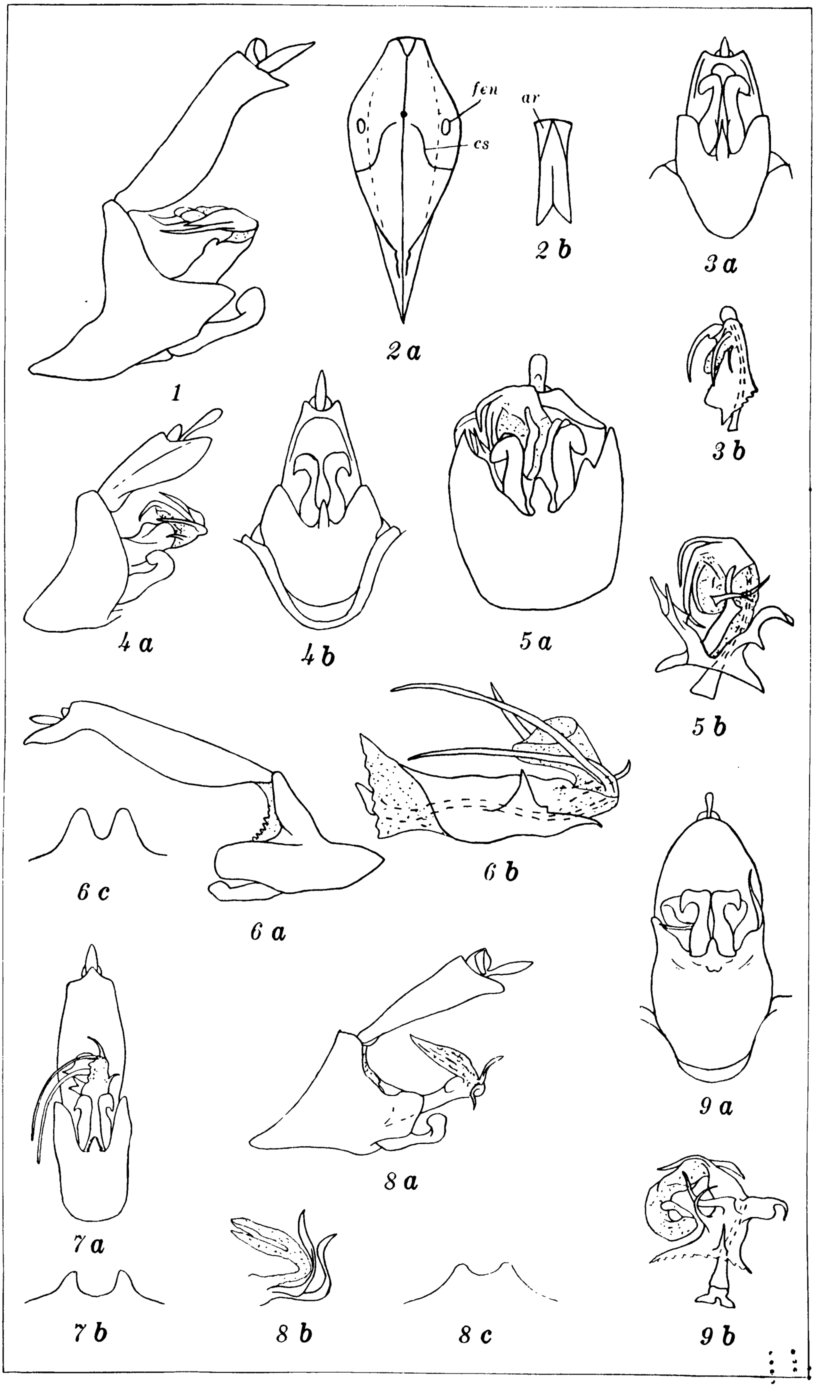

PLATE 1.

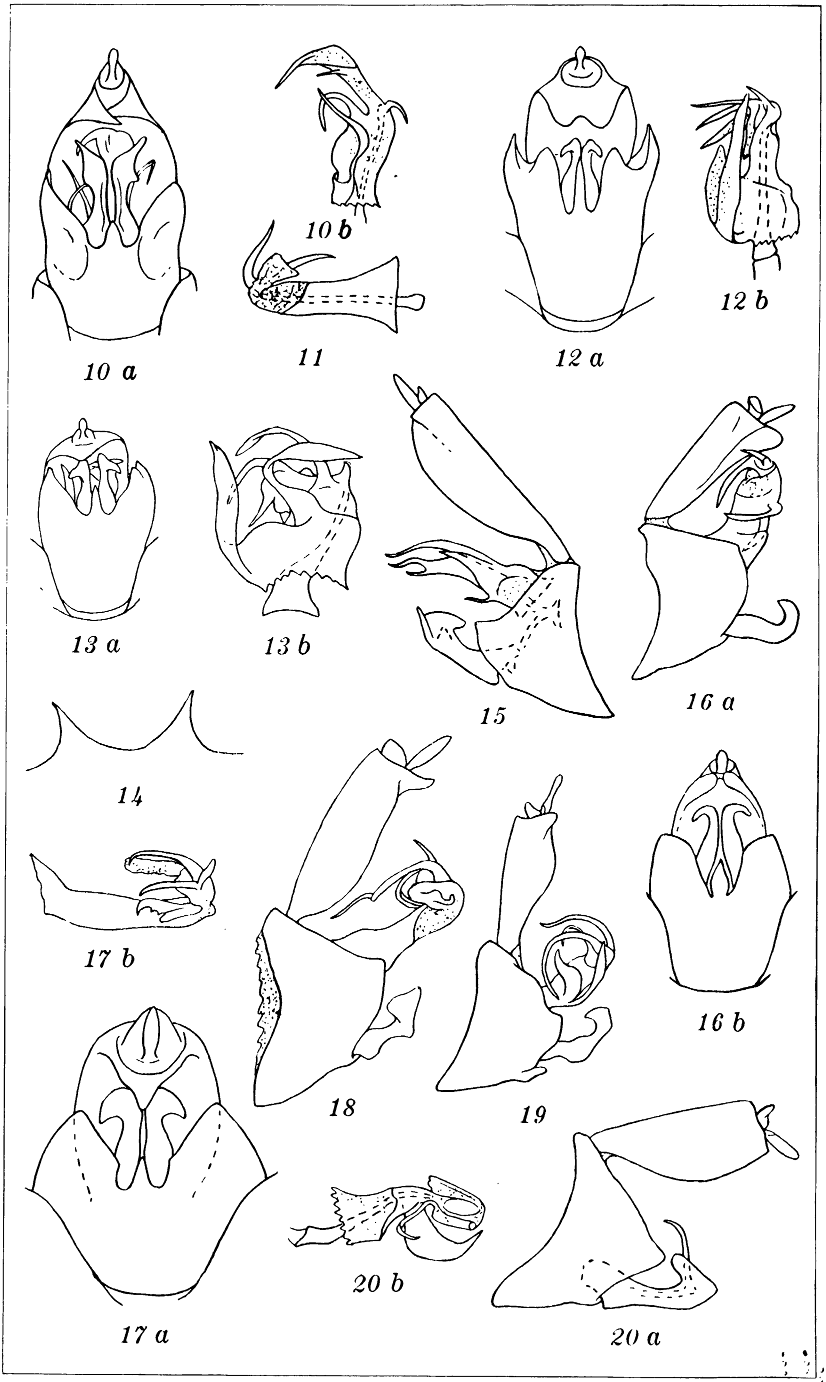

PLATE 2.

NEW OR LITTLE-KNOWN CRANE FLIES FROM NORTHERN JAPAN (TIPULIDÆ, DIPTERA)

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts[1]

TWO PLATES

During the summer of 1922, Teiso Esaki undertook an extensive collecting trip through Japanese Saghalien (Karafuto) and Hokkaido. Through the kind interest of Doctor Esaki, I have received the very extensive collections of Tipuloidea secured upon this expedition, these including more than one hundred species. It is no exaggeration to state that this is the largest and finest collection of crane flies that has yet been taken in Japan.

The species of Tipuloidea inhabiting Japan include a very curious admixture of forms that show affinities with others inhabiting the western Palæarctic, the Nearctic, and the Oriental Regions, as well as a small proportion of endemic genera and subgenera, though with an abundance of endemic species. This relationship is discussed in greater detail in the present paper. I am vastly indebted to Doctor Esaki for the gift of this splendid collection and for the accompanying discussion of his itinerary. All types and uniques are preserved in my collection, but certain paratypes and duplicates have been returned to Doctor Esaki.

GENERAL ACCOUNT OF THE EXPEDITION BY DOCTOR ESAKI

Saghalien.—Toyohara is the principal town of the island, located on the River Suzuya. To the east of the town there are small mountains of less than 500 feet in altitude, while east of these there is an extensive mountain range that averages more than 3,000 feet in altitude, culminating in Mount Suzuya, 3,454 feet, lying just east of Toyohara. These mountains are covered by coniferous forests, of which *Picea ajanensis* and *Abies sachalinensis* are the chief components. These two species are also found in Hokkaido, where they reach their southern limits. Crane flies appeared to be rather scarce in these mountains. Most of those from Toyohara were collected among the bushes along the river west of the town. Large trees are not plentiful there, the majority being trees of medium height, among them the following genera: *Betula, Alnus, Populus, Salix,* and *Ulmus,* lesser numbers of species of *Fagus* and *Quercus,* and a greatly reduced number of conifers, *Abies, Picea,* and *Larix.* The country is frequently swampy and the shrubs grow to a rather greater height than in Honshiu. A part of these flies were captured at light and at honey bait-traps.

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[1] Contribution from the Department of Entomology, Massachusetts Agricultural College.

Konuma lies about five miles north of Toyohara and under almost the same conditions, but the fauna seems more plentiful.

Sakaehama lies along the shore, the soil being mostly sandy, and the fauna and flora are very poor.

From Takinosawa to Shimizu (altitude about 1,000 feet) there was found a very abundant fauna, especially in butterflies. Unfortunately only a few tipulids were secured here. You probably found four examples of a medium-sized tipulid from Shimizu, whose wings are beautifully colored with hyaline and brown markings (*Polyangaeus gloriosus* sp. n.). This species was found near a valley where they fly in the evening, appearing as if entangled with one another.

The western coast of Saghalien (Honto, north to Kusunnai at 48° N. lat.) supports a very poor fauna, not only in crane flies but in almost all other groups.

From Kusunnai to Manui (northern limit reached by the expedition) the altitude is not so high as at Takinosawa (about 800 feet at Todorokitōge). Unfortunately while I was there the weather was inclement and collections here were not extensive. A destructive forest fire of a half century or more ago destroyed most of the larger trees, so that now there are only small specimens, mostly of *Betula alba.*

The eastern coast of Saghalien (Manui to Tonnai) is much richer in its fauna than the western coast. There are many marshes and pools along the coast but collecting is often interfered with by the windy weather. From Odomari to Tonnai (southeastern peninsula of Saghalien), we pass through extensive forests of *Abies* and *Picea.* These forests are severely attacked by a lasiocampid moth, *Dendrolimus sibiricus,* which has killed off a part of the trees.

Hokkaido.—Sapporo is the capital of Hokkaido, lying in the center of the Plain of Ishikari. In summer we have an abundant fauna, not only in the vicinity of the city, but within the city limits as well. Maruyama, just west of the city, is a most excellent collecting ground. The environment is very like that of Mount Minomo, in Settsu-no-kuni, central Honshiu, the streams in both cases being shaded by dense leafy shrubbery. Mount Moiwa, although at a higher altitude than Maruyama, seems to support a poorer fauna. The only tipulid collected there is a new species (*Discobola moiwana* sp. n.).

Jozankei is one of the best-known collecting grounds in all Japan. It is a bathing resort and has been much invaded by civilization within recent years, so its fauna is gradually becoming reduced. The vegetation along the valley is very dense. Kamuikotan, along the river Ishikari, is also a famous collecting spot in Japan, but the fauna is not so abundant as at Jozankei. Kamiotoineppu, in northern Teshio, proved to be a most excellent collecting ground. The extensive Experimental Forest of the Hokkaido Imperial University is located here. Most of the crane flies from this place were swept from trees and shrubs with spatulate leaves.

The very long-beaked species (*Elephantomyia hokkaidensis* sp. n.) which was afterwards found in many stations in Hokkaido, was found on the flowers of Compositæ, on which many insects, e. g., Syrphidæ, Apidæ, Lycaenidæ, and Hesperidæ, were feeding. This was true for all specimens collected, with the exception of a few that were attracted to light. No specimens were found on other flowers.

Shikaripetsu (Teshio) and Kamiokoppe (Kitami) are on the two sides of the boundary between Teshio and Kitami. The conditions are very similar to those obtaining at Kamiotoineppu (all being mountainous but not exceeding 1,000 feet in altitude), but the fauna is much poorer.

Abashiri (Northeastern Kitami) provides excellent collecting grounds in the vicinity of the town. Specimens dated August 30th were collected on Mount Sanchozan, at an altitude of 500 feet or more, about two miles northwest of the town, and in the Abies forests at Moyoro at night [a pair of the large and beautiful *Pedicia daimio* (Matsumura), a single *Nesopeza geniculata* Alexander, and *Elephantomyia hokkaidensis* were captured here at light]. The collection dated August 31st is from the town proper.

Akan is the name of a lake in the northern extremity of the Province of Kushiro. It is one of the most interesting and beautiful lakes in Hokkaido, or even in all Japan, but it is very inconvenient to visit there. The fauna is probably a very rich one although the season during which my trip was made was not a good one. In the lake can be seen a very curious alga, *Ægagropila sauteri*, about the shape and size of a base-ball, which is spread over the bottom of a part of the lake and can be clearly

TABLE 1.—*Stations at which collections of Tipulidæ were made.*

SAGHALIEN

Japanese name.	Russian name.	Approximate location.	Approximate altitude in feet.
Higashi-shiraura	Shiraraka	East	Sea level.
Honto		West	Do.
Kawakami		South	Less than 500.
Kiminai	Kimnai	do	Less than 800.
Konuma	Novalexandrovsk	do	Very low.
Kusunnai		West	Sea level.
Manui		East	Do.
Maoka	Mauka	West	Do.
Minakishi		South	Low.
Nayoro		West	Sea level.
Nodasam		do	Do.
Ochiho		South	Do.
Odasam		East	Do.
Odomari	Korsakoff	South	Do.
Oite		West	Sea level.
Sakaehama		East	Do.
Shimizu		South	About 1,000.
Takinosawa		do	Do.
Todorokitōge		North	About 800.
Tomarioro		West	Sea level.
Tonnai	Tonnaitcha	South	Do.
Toyohara	Vladimiroffea	do	Very low.

TABLE 1.—*Stations at which collections of Tipulidæ were made*—Continued.

HOKKAIDO

Station.	Province (Ken).	Approximate altitude in feet.
Abashiri	Kitami	Sea level.
Akan (lake)	Kushiro	1,400.
Akkeshi	do	Sea level.
Biporo	Kitami	Very low.
Hakodate	Oshima	Sea level.
Jozankei	Ishikari	About 1,000.
Kamiokoppe	Kitami	Less than 1,000.
Kamiotoineppu	Teshio	Do.
Kamuikotan	Ishikari	About 800.
Kushiro	Kushiro	Sea level.
Kutchan	Iburi	Very low.
Maruyama	Ishikari	750.
Meakantake (volcano)	Kushiro	5,340.
Moiwa (Mount)	Ishikari	1,750.
Nayoro	Teshio	Low.
Nokkeushi	Kitami	Very low.
Onuma	Oshima	Do.
Otanoshike	Kushiro	Sea level.
Panketo	do	1,500.
Ponkikin	Kitami	Less than 500.
Sapporo	Ishikari	60.
Shikaripetsu	Teshio	Less than 1,000.
Shikotsu (lake)	Iburi	850.
Shitakara	Kushiro	Less than 500.
Teppetsu	do	Do.
Tomakomai	Iburi	Sea level.
Tsubetsu	Kitami	Less than 500.

seen through the very limpid water. (The stations Biporo, Tsubetsu, Ponkikin (Kitami), Panketo, Teppetsu, Shitakara, Otanoshike and Kushiro (Kushiro) are in the eastern part of Hokkaido).

Kushiro and Akkeshi are on the southeastern coast and the weather is very frequently misty. They do not support a rich fauna. Shikotsu (in Iburi) is likewise a very famous lake in Hokkaido. The water is even clearer than that of Lake Akan. The margins of the lake are covered with very rich vegetation which afford really excellent collecting.

COMPONENTS OF THE CRANE-FLY FAUNA OF NORTHERN JAPAN

The majority of the genera and species of crane flies so far discovered in northern Japan are evidently derived from, or find their closest relatives in, the Holarctic Region. However, a certain considerable proportion have evidently been derived from the west (Europe) while others are as clearly derived from the east (North America). In addition to the above, and to numerous endemic species, there has been a notable invasion of genera and species from the south, though many of these oriental types do not reach the northern island of Japan (*Thrypti-*

comyia, Euglochina, Styringomyia, Gymnastes, Trentepohlia, Ctenacroscelis, Tipulodina, and others) but reach their northern limit at about the latitude of Tokyo, or slightly farther north in Honshiu.

With the above facts in mind, the Tipuloidea that were taken by Doctor Esaki may be roughly divided into the following groups:

1. Endemic groups.

Proantocha, a subgenus.
Tipulidæ, most of the species of this family, in various genera.

2. Genera and species evidently derived from the western Palæarctic Region.

Dicranomyia megacauda sp. nov.
Limonia quadrinotata (Meigen).
Limonia annulus truncata subsp. nov.
Limonia bifasciata avis Alexander.
Limnophila japonica Alexander.
Limnophila nemoralis (Meigen) var.
Erioptera (*Acyphona*) *sachalina* sp. nov.
Erioptera (*Acyphona*) *yezoana* sp. nov.
Cheilotrichia imbuta (Meigen).
Nephrotoma dorsalis sachalina subsp. nov.
Nephrotoma aculeata atricauda subsp. nov.
Nephrotoma cornicina Linnæus var.
Nephrotoma lamellata Riedel var.
Tipula variicornis Schummel.
The genera *Psiloconopa* and *Dictenidia* in Honshiu also show this relationship.

3. Genera and species evidently derived from the Nearctic Region.

Dicranomyia globulithorax sp. nov.
Discobola moiwana sp. nov.
Discobola argus (Say).
Limonia neoindigena sp. nov.
Rhaphidolabina.
Polyangaeus.
Eriocera sachalinensis sp. nov.
Eriocera jozana sp. nov.
Erioptera (*Hoplolabis*) *asiatica* Alexander.
Ormosia subdeviata sp. nov.
Gnophomyia tristis sp. nov.
Neolimnophila ultima (Osten Sacken) var.
Oropeza satsuma Alexander.

4. Genus evidently derived from the Neotropical Region.

Paratropesa esakii sp. nov.

5. Genera and species evidently derived from the Oriental Region.

Rhipidia pulchra septentrionis Alexander.
Libnotes longistigma Alexander.
Libnotes nohirai Alexander.
Gonomyia (*Lipophleps*) *flavocostalis* sp. nov.
Conosia irrorata (Wiedemann).
Nesopeza geniculata Alexander.
Tipula nova Walker.

6. Holarctic types.

Rhipidia maculata Meigen.
Dicranomyia longipennis (Schummel).
Elliptera.
Pedicia.
Ula.
Acyphona.
Helobia hybrida Meigen.
Tanyptera.
Ctenophora.

From the above data it can readily be seen that the chief affinities of the tipulid fauna of northern Japan are with other parts of the Holarctic Region. A concrete comparison of the known Tipulidæ of three widely separated localities in the Holarctic Region has been tabulated. These regions are northern Japan (Saghalien and Hokkaido), in the eastern Palæarctic Region; Lapland, in the western Palæarctic Region; and the State of Maine in the northeastern Nearctic Region.

TABLE 2.—*Comparison of known Tipulidæ in three widely separated localities in the Holarctic Region.*

[An asterisk indicates that the genus has been taken in Honshiu, although not known to occur in the northern island of Japan.]

Genus.	Northern Japan.	Lapland.	Maine.	Genus.	Northern Japan.	Lapland.	Maine.
Ptychoptera	1	0	1	*Polyangaeus*	1	0	0
Bittacomorpha	0	0	1	*Rhaphidolabis*	2	1	2
Bittacomorphella	0	0	1	*Dicranota*	1	4	0
Trichocera *	0	3	2	*Molophilus*	1	3	3
Dicranomyia	9	11	13	*Erioptera*, s. l.	9	7	11
Rhipidia	2	1	2	*Cheilotrichia*	1	0	0
Geranomyia	1	0	2	*Psiloconopa* *	0	2	0
Discobola	3	1	1	*Helobia*	1	1	1
Limonia	13	3	8	*Cryptolabis*	0	0	1
Libnotes	2	0	0	*Gnophomyia*	1	0	1
Helius	1	1	1	*Gonomyia*, s. l.	4	0	2
Elliptera	1	0	0	*Rhabdomastix* *	0	1	0
Dicranoptycha	1	0	0	*Paratropesa*	1	0	0
Antocha	6	0	1	*Teucholabis*	1	0	0
Orimarga	0	1	0	*Toxorhina*	0	0	1
Ula	2	1	1	*Neolimnophila*	1	0	1
Epiphragma	1	0	1	*Cladura* *	0	0	1
Dactylolabis *	0	0	1	*Chionea*	1	2	0
Limnophila, s. l.	7	8	12	*Cylindrotoma*	1	1	1
Pseudolimnophila *	0	0	4	*Liogma*	0	0	1
Idioptera	0	3	1	*Phalacrocera* *	0	1	1
Phyllolabis	0	1	0	*Dolichopeza*	0	1	1
Ulomorpha	0	0	1	*Oropeza*	1	0	4
Pilaria	1	0	5	*Nesopeza*	1	0	0
Hexatoma *	0	1	0	*Ctenophora*	1	0	1
Eriocera	2	0	2	*Tanyptera*	1	2	1
Elephantomyia	1	0	1	*Dictenidia* *	0	1	0
Adelphomyia	0	0	3	*Pselliophora*	1	0	0
Pedicia	1	2	1	*Prionocera*	0	4	1
Tricyphona *	0	1	5	*Nephrotoma*	8	1	10
Rhaphidolabina	1	0	1	*Tipula*	18	29	30

The most surprising features of the crane-fly fauna of the region under consideration will be noted from a study of Table 2. These are the great abundance of species of the genera *Limonia* and *Antocha;* the lack of genera such as *Tricyphona* and *Phalacrocera;* the occurrence of a species of the genus *Paratropesa,* otherwise known only from tropical America.

PUBLISHED REFERENCES TO THE TIPULID FAUNA OF SAGHALIEN AND HOKKAIDO

The crane-fly fauna of Saghalien has been virtually unknown. The only collections that have been made in the past seem to be those discussed by Matsumura (1911), a small collection taken by Paul Labbé in 1902 and now preserved in the Paris Museum, and a few specimens taken by Satoru Kuwayama in 1921 and kindly sent by him to me. The latter records have been included in the present paper.

Matsumura's paper (1911) cited above is the first and only published account of this interesting fauna. In that paper he records the following species:

Xiphura macra Loew from Solowiyofka; this probably equals the *Tanyptera jozana* (Matsumura) var. of the present paper, and is certainly not *T. gracilis* (Portschinsky), the prior name of *Xiphura macra.*

Tipula paludosa Meigen, recorded doubtfully, but the occurrence of this species in eastern Asia would not be surprising.

Tipula variicornis Schummel, recorded from Tonnaitcha (as *Pachyrhina annulicornis* Meigen).

In addition to these, Matsumura describes as new the following:

Limnobia sachalinensis sp. nov. This certainly is not a *Limonia,* but very possibly a *Limnophila* (vein M_{1+2} forked).

Metalimnobia vittata gen. et sp. nov. The indentity of this is uncertain, but it is possibly a *Limonia,* because of the toothed ungues.

Neither of the above species was taken by Doctor Esaki.

The crane flies of Hokkaido are rather better known than are those of Saghalien, though still insufficiently when compared with the extensive and fairly complete list from Honshiu. All of the species hitherto recorded from Hokkaido are included in papers by Matsumura and by me which are included in the bibliography at the end of this paper. All of the species of Tipulidæ from Japan, described by Coquillett, Edwards, Enderlein, Loew, Westwood, and others seem to have been taken in the main island of the Empire.

PTYCHOPTERIDÆ

Genus **PTYCHOPTERA** Meigen

Ptychoptera MEIGEN, Illiger's Mag. 2 (1803) 262.

The only species of *Ptychoptera* taken on the present expedition was *P. subscutellaris* Alexander, hitherto known only from Hokkaido.

Ptychoptera subscutellaris Alexander.

Ptychoptera subscutellaris ALEXANDER, Insec. Inscit. Menst. 9 (1921) 81–83.

Saghalien: Konuma, July 17, 1922 (*Esaki*); Toyohara, July 24, 1922 (*Esaki*).

The femora and tibiæ are more conspicuously blackened apically than in the types from the vicinity of Sapporo.

TIPULIDÆ

TRIBE LIMNOBIINI

Genus **DISCOBOLA** Osten Sacken

Discobola OSTEN SACKEN, Proc. Ent. Soc. Phila. (1865) 226.

The genus *Discobola* includes thirteen described species, eight of which are known only from New Zealand. The occurrence of undescribed species of this genus in Japan has been known to me for many years. In the present collection, no fewer than three species were included, two of which are considered as being undescribed, while the third cannot be distinguished from the *Discobola argus* (Say) of eastern North America. The Holarctic species of *Discobola* may be separated as follows:

Key to the Holarctic species of the genus Discobola.

1. The spot on costal margin of wing surrounding tip of vein Sc solid.... 2.
   The spot on costal margin of wing surrounding tip of vein Sc not solid, there being small hyaline dots in the outer ends of cells C and Sc.... 3.
2. Cell M without small brown clouds; mesal face of ventral dististyle of male hypopygium produced mesad into a beak. (Western Palæarctic Region.) .... **D. annulata** (Linn.).
   Cell M with brown clouds and marblings; mesal face of ventral dististyle of male hypopygium not produced into a beak. (Western Palæarctic Region.) .... **D. caesarea** (O. S.).
3. Antennæ with the second segment light yellow; halteres black, the bases of stem and knob light yellow; femora yellow with a very narrow, brown, subterminal ring, the pale apex beyond it much broader; wings with a concentric ocellate pattern, the rings being double. (Eastern Palæarctic Region.) .... **D. margarita** sp. nov.

Antennal scape uniformly black; bases of knobs of halteres black; femora yellow with a black subterminal ring that is much more extensive than the yellow apex; wings with an ocellate pattern, the rings single.. 4.

4. Mesonotal prescutum without distinct stripes, brown with a sparse yellowish pollen; halteres yellow, only base of knob black. (Eastern Palæarctic Region.)........................ **D. moiwana sp. nov.**

Mesonotal prescutum distinctly striped with black; halteres with the stem black.. 5.

5. Thoracic pleura conspicuously silvery pruinose; antennal flagellum paler than scape. (Western Nearctic Region.)............... **D. elegans** (Doane).

Thorocic pleura inconspicuously silvery; antennæ black throughout (Nearctic Region and eastern Palæarctic Region.)........ **D. argus** (Say).

Discobola margarita sp. nov.

General coloration yellow; antennæ black, the second segment conspicuously light yellow; a narrow brown longitudinal stripe on lateral margins of pronotum and prescutum and another on dorsal pleurites; halteres black, base of stem and knob light yellow; femora with a very narrow, brown, subterminal ring; wings with an ocellate pattern, the outer rings of which are double, each having a pale center; abdominal segments brownish yellow, the caudal margins very narrowly brown.

Male, length, 7 to 8 millimeters; wing, 7.2 to 8.2. Female, length, 8 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ black, the second scapal segment abruptly light yellow. Head black, grayish pruinose. Pronotum shiny yellow, sides dark brown. Mesonotal prescutum and scutum yellow, the lateral margins of the former conspicuously dark brown; scutellum and postnotum obscure yellow, the latter with the posterior margin infuscated. Pleura brownish yellow, with a conspicuous dark brown longitudinal stripe extending from behind fore coxæ onto the pleurotergites of postnotum; sternopleura ventrad of this area covered with an appressed silvery pubescence; the dark longitudinal stripes of dorsum and pleuron described above are separated from one another by the pale dorsopleural membrane. Halteres black, base of stem and bases of knobs conspicuously light yellow, remainder of knobs brownish black. Legs with coxæ and trochanters obscure yellow; femora concolorous with a very narrow and indistinct brown subterminal ring some distance before tips; in some specimens, this ring is almost obliterated; tibiæ and tarsi yellow, the terminal tarsal segments dark brown. Wings yellow with a very heavy ocellate pattern, arranged about as in *Discobola argus;* the centers of the ocellate markings are solid but the rings are double, each having a pale center with narrow dark margins; the general effect of this type of marking is a very abundant, delicate brown marking. Venation: Cell 1st M_2 elongate, tending to be irregular in outline, m being much shorter than the outer deflection of M_3, the latter angulate just beyond midlength. In the female, the cell is more regularly rectangular in outline. Abdomen brownish yellow, the caudal margins of the segments narrowly but conspicuously dark brown.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Kamiotoineppu, Hokkaido, August 24, 1922 (*T. Esaki*).

Allotype, female, Kusunnai, Saghalien, August 2, 1922 (*T. Esaki*).

Paratopotypes, 2 males; paratype, male, Jozankei, Hokkaido, August 19, 1922 (*T. Esaki*).

This exquisite fly is one of the most distinct species of the genus so far discovered. It is named in honor of my wife, Mabel M. Alexander.

Discobola moiwana sp. nov.

Female, length, about 9 millimeters; wing, 9.5.

Generally similar to *Discobola argus* (Say), from which it differs as follows:

Mesonotal prescutum without distinct stripes, rather uniformly dark brown with a sparse yellowish pollen. Longitudinal brown pleural stripe very narrow, the silvery pleural areas correspondingly extensive. Halteres yellow, only bases of knobs black. Yellow femoral tips narrower. Wings with cell M marbled with brown; supernumerary cross vein in cell 1st A longer than vein 2d A beyond it.

Habitat.—Japan (Hokkaido).

Holotype, female, Mount Moiwa, September 17, 1922 (*T. Esaki*).

Discobola argus (Say).

Limnobia argus SAY, Long's Exped., Append. (1824) 358.

One female, Akan, Hokkaido, September 4, 1922 (*T. Esaki*).

I have compared this specimen critically with an extensive series of Nearctic *Discobola argus*, and can find no differences that can be considered as being of even subspecific value. It is possible that the male sex will show such differences, but this sex is not available at the present time. This is the first record of a Nearctic crane fly occurring in Japan that does not also occur in Europe.

All three species of *Discobola* recorded in this paper as from Japan are very different from the two European forms.

Genus **GERANOMYIA** Haliday

Geranomyia HALIDAY, Ent. Mag. 1 (1833) 154.

Geranomyia avocetta Alexander.

Geranomyia avocetta ALEXANDER, Can. Ent. 45 (1913) 205, 206.

One small female, Toyohara, Saghalien, July 13, 1922 (*T. Esaki*).

Genus **RHIPIDIA** Meigen

Rhipidia MEIGEN, Syst. Beschr. 1 (1818) 153.

Rhipidia maculata Meigen.

Rhipidia maculata MEIGEN, Syst. Beschr. 1 (1818) 153, pl. 5, fig. 11.

This species has a very extensive range throughout the North Temperate regions of the world. The following records are available from the present collection:

Saghalien: Toyohara, July 13 to 23, 1922 (*T. Esaki*); Takinosawa, July 26, 1922 (*T. Esaki*); Ôdomari, August 9, 1922 (*T. Esaki*). Hokkaido: Jozankei, August 19, 1922 (*T. Esaki*); Kamuikotan, August 22, 1922 (*T. Esaki*); Kamiotoineppu, August 23 and 24, 1922 (*T. Esaki*).

The number of spines on the rostrum of the dististyle of the male hypopygium runs as high as seven.

Rhipidia pulchra septentrionis Alexander.

Rhipidia pulchra septentrionis ALEXANDER, Can. Ent. 45 (1913) 206, 207, pl. 3, fig. 1.

As indicated in other papers, this species runs very close to *Dicranomyia* and may more properly be considered as belonging to that genus. The following records are available from the present collection, all the specimens having been taken by Doctor Esaki:

Saghalien: Toyohara, July 20, 1922. Hokkaido: Jozankei, August 19, 1922; Kamuikotan, August 22 and 23, 1922; Kamiotoineppu, August 25, 1922; Shikaripetsu, August 26, 1922; Kamiokoppe, August 27, 1922; Akkeshi, September 11, 1922.

Genus **DICRANOMYIA** Stephens

Dicranomyia STEPHENS, Cat. Brit. Ins. 2 (1829) 243.

This very extensive genus was well represented in number of species.

Dicranomyia mesosternata Alexander.

Dicranomyia mesosternata ALEXANDER, Ann. Ent. Soc. Am. 12 (1919) 329, 330.

Doctor Esaki collected the following material: Saghalien: Toyohara, July 20 to 23, 1922, including one female at honey bait trap. A male from this material has cell 1st M_2 open by the atrophy of m in both wings. Hokkaido: Sapporo, August 17 to 19 and September 7, 1922; Abashiri, August 31, 1922; Akan, September 3 to 7, 1922; Panketo, September 6, 1922.

Dicranomyia longipennis (Schummel).

Limnobia longipennis SCHUMMEL, Beitr. zur Ent. 1 (1829) 104, pl. 1, fig. 2.

This species is distributed throughout the Holarctic Region. The author had already recorded it from Honshiu.[2] The following material from Hokkaido was included in the present collection:

Sapporo, August 18, 1922 (*T. Esaki*); Kamiotoineppu, August 23, 1922 (*T. Esaki*).

In the right wing of the Sapporo specimen, cell 1st M_2 is closed by the retention of m; the left wing is normal.

Dicranomyia immodestoides Alexander.

Dicranomyia immodestoides ALEXANDER, Ann. Ent. Soc. Am. 12 (1919) 327, 328.

This species has a wide range in Honshiu. It is included from Saghalien and Hokkaido as a result of the following specimens collected by Doctor Esaki:

Saghalien: Toyohara, July 13 to 25, 1922; Maoka, July 28, 1922; Kusunnai, August 2, 1922. Hokkaido: Sapporo, August 17, September 13 to 26, 1922; Jozankei, August 19, 20, 1922; Kamuikotan, August 22, 1922; Kamiotoineppu, August 23, 24, 1922; Shikotsu, September 24, 1922; Tomakomai, September 25, 1922; Onuma, September 27, 1922.

Dicranomyia subtristis sp. nov.

Related to *D. tristis* (Schummel) of the Western Palaearctic Region. General coloration gray, the prescutum with a broad, brown, median stripe; male hypopygium with spines of rostrum elongate, arising from long, enlarged bases that are connate basally.

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[2] Trans. Am. Ent. Soc. 46 (1920) 1.

Male, length, 5.6 millimeters; wing, 7.4. Female, length, 5.5 millimeters; wing, 7.

Rostrum and palpi black. Antennæ black throughout. Head light gray, vertex between eyes relatively narrow. Mesonotal prescutum gray with a broad, medium dark brown stripe, the anterior end of which is indistinctly bifid; lateral stripes very small to nearly obsolete; remainder of mesonotum gray, the scutal lobes dark brown. Pleura dark gray. Halteres yellow, knobs infuscated. Legs with coxæ dark gray; trochanters obscure yellow; remainder of legs dark brown, basal half of each femur obscure yellow. Wings faintly tinged with gray; stigma small, brown, surrounding r; veins brown, those in the costal region somewhat paler. Venation: Sc_1 ending opposite or immediately before origin of Rs, Sc_2 close to its tip; Rs gently arcuated, about one-half longer than the basal deflection of R_{4+5}; cell 1st M_2 about as long as vein M_3 beyond it; basal deflection of Cu_1 a short distance before fork of M. Abdomen dark brown, the genital segment paler. Male hypopygium (Plate 1, fig. 1) with basistyles short and stout, the caudal lateral angle produced into a blunt point; dorsal face of basistyle with a small setiferous lobe; mesal face of basistyle produced caudad into a long, relatively stout lobe; ventral dististyle yellow, the mesal face produced mesad into a slender rostrum that bears far out toward its apex two elongate spines whose bases are enlarged and united for about one-half their length; dorsal dististyle suddenly narrowed into an acute spine at tip as in the *tristis* group of species.

In *tristis*, the basistyle has the lobes slenderer; the spines of the rostrum of the ventral dististyle from short, separate bases, the apex beyond them long-produced; a linear row of about five long setæ near the base of the rostrum.

Habitat.—Japan (Hokkaido).

Holotype, male, Kamuikotan, August 22, 1922 (*T. Esaki*).

Allotopotype, female.

American species of the *tristis* group include *D. liberta* Osten Sacken, *D. libertoides* Alexander, and *D. knabi* Alexander.

Dicranomyia sachalina sp. nov.

General coloration gray; rostrum and palpi brownish black; antennæ black; prescutum with an ill-defined stripe; wings very faintly darkened; stigma oval, pale brown; Sc short, cell 1st M_2 closed; hypopygium with rostrum of the ventral dististyle short, bispinous; dorsal diststyle short and strongly curved.

Male, length, about 6 millimeters; wing, 6.5. Female, length, 7 to 7.5 millimeters; wing, 7 to 8.

Rostrum and palpi brownish black. Antennæ black throughout. Head dark gray. Pronotum and mesonotum dark, covered with an abundant gray pruinosity, prescutum with an ill-defined median stripe on the anterior portion; pruinosity on scutellum and postnotum lighter gray. Pleura light gray pruinose. Halteres pale, knobs dark brown. Legs with coxæ and trochanters obscure yellow; femora obscure yellow, passing into brown before tips; remainder of legs dark brown. Wings very faintly tinged with darker; stigma oval, pale brown; veins pale brown, those at wing base paler. Venation: Sc short, Sc_1 ending just beyond origin of Rs, Sc_2 some distance from tip of Sc_1, the latter alone about equal to the basal deflection of M_{1+2}; Rs arcuated, about twice the length of R_{2+3}; cell 1st M_2 closed; basal deflection of Cu_1 at fork of M. Abdomen dark brown, the genital segment paler. Male hypopygium with basistyles relatively short, the mesal face produced into stout lobes that are very densely set with microscopic setæ and setulæ, apex slender and provided with a few conspicuous setiferous tubercles. Ventral dististyle fleshy, the mesal face produced into a relatively short beak that bears two subequal spines, these not widely separated; dorsal dististyle a short, powerful, strongly curved hook. Ninth tergite with a broad, rectangular, median notch. Ovipositor with the valves relatively stout.

Habitat.—Japan (Saghalien).

Holotype, male, Sakaehama, July 20, 1922 (*T. Esaki*).

Allotype, female, Toyohara, July 19, 1922 (*T. Esaki*).

Paratopotype, 1 female; paratypes, 3 females, with the allotype, July 15 to 20, 1922; 1 female, Odasam, August 6, 1922 (*T. Esaki*).

Dicranomyia sachalina bears a superficial resemblance to *D. subtristis*, but is a very different fly. The stigma is full though pale, in *D. subtristis* being a narrow seam to r.

Dicranomyia sparsa sp. nov.

General coloration yellowish brown, prescutum with three slightly darker stripes; legs yellow, tips of femora and tibiæ faintly darkened; wings strongly tinged with yellow, stigma bicolorous; veins pale, cord and outer end of cell 1st M_2 dark brown; Sc_1 longer than Rs.

Female, length, 7.5 millimeters; wing, 7.6.

Rostrum short, pale brownish testaceous, mouth parts greenish, palpi pale brown. Antennæ brown, the flagellar segments oval. Head brownish gray. Mesonotal prescutum yellowish brown with three darker stripes, the median stripe more brownish, the lateral stripes more grayish; scutum with the narrow central portion gray, lobes brown, margined mesially by yellow; scutellum yellow, with a narrow, gray, median area; postnotum brownish testaceous. Pleura pale brown, very indistinctly variegated with gray. Halteres very short, with large knobs, pale, knobs a little darker. Legs with coxæ and trochanters pale testaceous, femora, tibiæ, and basitarsi yellow, tips very indistinctly darkened; terminal tarsal segments brown. Wings strongly tinged with yellow, base and costal region more saturated; stigma pale brown, the narrow part surrounding r darker brown, producing a bicolorous stigmal area; veins pale, cord and outer end of cell 1st M_2 conspicuously dark brown to produce the appearance of a faintly darkened wing. Venation: Sc short, Sc_1 ending a short distance beyond origin of Rs; Sc_2 far from tip of Sc_1 so the latter vein alone is longer than Rs; Rs nearly straight, with several macrotrichiæ; cell 1st M_2 closed, longer than the veins issuing from it; basal deflection of Cu_1 close to fork of M. Abdominal tergites dark brown, the caudal margin of basal segments indistinctly pale; basal sternites yellowish. Ovipositor with the tergal valves slender.

Habitat.—Japan (Saghalien).

Holotype, female, Toyohara, July 23, 1922, at honey bait trap (*T. Esaki*).

Dicranomyia spinicauda sp. nov.

General coloration yellowish brown; rostrum orange; mesonotal prescutum with three brown stripes; wings faintly tinged with brownish yellow; Sc short, Sc_1 long; cell 1st M_2 closed; male hypopygium with the two spines of rostrum widely separated; mesal face of ventral dististyle beyond rostrum densely set with spinous setæ.

Male, length, 5.5 millimeters; wing, 6.5 to 7. Female, length, 6.5 to 6.8 millimeters; wing, 7.2 to 7.5.

Rostrum orange, the palpi conspicuous, dark brown. Antennæ with first scapal segment orange; remainder of antennæ dark brown. Head gray. Pronotum dark brown, the lateral margins paler. Mesonotal prescutum yellowish brown, with a broad, conspicuous median and less distinct lateral stripes;

scutum yellow, the lobes dark brown; scutellum dark brown, broadly yellow medially; postnotum dark brown medially, the pleurotergite pale. Pleura pale, sparsely pollinose, the sternopleura darkened. Halteres dark brown, the base of stem narrowly pale. Legs with the coxæ and trochanters yellow; femora brownish yellow indistinctly darker toward tips; tibiæ and tarsi passing into dark brown. Wings faintly tinged with brownish yellow, base and costal region a little brighter; veins brown. Venation: Sc short, Sc_1 ending before origin of Rs; Sc_2 some distance before tip of Sc_1, the latter alone a little longer than the basal deflection of R_{4+5}; cell 1st M_2 closed; basal deflection of Cu_1 at fork of M. Abdomen dark brown, the basal sternites paler; hypopygium obscure brownish yellow. Male hypopygium (Plate 1, fig. 5) with basistyles relatively slender, the mesal face produced mesad into a very broad, triangular lobe; ventral dististyle fleshy, the mesal face at base produced into a slender rostrum that bears two very widely separated spines, the outer one shortly before tip, the shorter inner spine before midlength of rostrum; mesal face of ventral dististyle caudad of rostrum densely set with abundant spinous setæ; dorsal dististyle slender, strongly curved to the acute tip. Gonapophyses bifid by a very deep U-shaped notch, the mesal lobe thus formed slender.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Toyohara, Saghalien, July 15, 1922 (*T. Esaki*).

Allotopotype, female, July 14, 1922 (*T. Esaki*).

Paratopotypes, 3 males, 1 female, July 17 to 25, 1922; paratype, 1 male, Otanoshike, Hokkaido, September 12, 1922 (*T. Esaki*).

Dicranomyia megacauda sp. nov.

Related to *D. magnicauda* Lundström (Northern Europe), differing chiefly in the details of structure of the male hypopygium; prescutum with a single dark stripe.

Male, length, 5.5 millimeters; wing, 6.8. Female, length, 6.5 millimeters; wing, 7.5.

Rostrum pale orange, the palpi dark brown. Antennæ dark brown throughout. Head dark gray, the anterior part of vertex pale gray. Pronotum dark brown, paler laterally. Mesonotal prescutum pale reddish brown with a single median dark brown stripe that becomes obliterated before suture; remainder of mesonotum pale reddish brown, indistinctly pollinose. Pleura ocherous, very indistinctly striped longitudinally with darker. Halteres elongate, pale yellow, knobs dark brown. Legs with coxæ and trochanters pale testaceous; femora pale brown, tibiæ and tarsi gradually passing into dark brown. Wings subhyaline, stigma pale brown; veins darker brown. Venation: Sc_1 ending immediately beyond origin of Rs, Sc_2 some distance from tip of Sc_1 the latter vein alone about equal to basal deflection of Cu_1; Rs long, nearly straight, in alignment with R_{2+3} basal deflection of R_{4+5} nearly one-half Rs; basal deflection of Cu_1 close to fork of M; both wings of type with malformed venation, in the presence of adventitious cross veins between R_{4+5} and M_{1+2}. Abdomen dark brown, sternites yellow. Male hypopygium very large and complicated in structure, generally similar in fundamentals to *D. magnicauda* Lundström; rostriform appendage arising as a conspicuous arm from base of ventral dististyle, shaped as in figure (Plate 1, fig. 2); dorsal dististyle almost straight, apex suddenly narrowed into a stout spine. From the ventromesal face of each basistyle arises the complex structure shown in Plate 1, fig. 3. Female generally similar to male but general coloration of body more ocherous; halteres somewhat shorter; Sc not attaining base of the shorter and more arcuated Rs; ovipositor with the valves comparatively short but slender.

Habitat.—Japan (Saghalien.)

Holotype, male, Toyohara, July 20, 1922 (*T. Esaki*).

Allotopotype, female.

Dicranomyia globulithorax sp. nov.

Related to *D. globithorax* Osten Sacken; mesonotum less gibbous; wings strongly tinged with blackish; male hypopygium with a single dististyle, the mesal face of which is truncated and densely set with numerous spinous setæ.

Male, length, 5.5 millimeters; wing, 5.8 to 6.

Rostrum and palpi very short, black. Antennæ black throughout, the basal flagellar segments nearly globular, the terminal segments passing through oval to elongate. Head dark brown. Mesonotum dark brown, slightly less gibbous than in *D. globithorax* O. S. Halteres dark brown, base of stem narrowly pale. Legs with coxæ and trochanters obscure testaceous; remainder of legs brownish black. Wings strongly tinged with blackish; stigma indistinct; veins dark brown. Venation: Sc long, ending beyond midlength of the long, straight sector, Sc_2 at tip of Sc_1; a supernumerary cross vein in cell Sc_1, as in *D. globithorax*, this from once to twice its length before r; tip of R_1 beyond r atrophied; cell 1st M_2 closed; basal deflection of Cu_1 close to or beyond fork of M, longer than Cu_1. Abdomen dark brown, the basal sternites paler. Male hypopygium (Plate 1, fig. 4) with basistyle produced into a slender, fleshy lobe on mesal face; a single dististyle, this fleshy, the mesal face broadly truncated and densely set with abundant, stout, black spinous setæ.

Habitat.—Japan (Hokkaido).

Holotype, male, Shikotsu, September 27, 1922 (*T. Esaki*).

Paratopotype, male.

Genus **LIMONIA** Meigen

Limonia MEIGEN, Illiger's Mag. 2 (1803) 262.
Limnobia MEIGEN, Syst. Beschr. 1 (1818) 116.

The name *Limonia* must be used in place of *Limnobia* Meigen, it having unquestioned priority. The genus is very rich in species throughout the Japanese Empire, more than a dozen species being included in the present collection. As has been indicated by the author and other writers in other papers, the smaller species of *Limonia* run very close to those of *Dicranomyia* on the one hand, and to those of *Geranomyia* and *Rhipidia* on the other. Strict generic criteria, if such exist, are desiderata.

Limonia quadrinotata (Meigen).

Limnobia quadrinotata MEIGEN, Syst. Beschr. 1 (1818) 144.

The following records are available in Esaki's material: Hokkaido: Abashiri, August 30, 1922; Akan, September 3, 1922.

I cannot detect any differences between the Japanese specimens and a series from various countries of central and northern Europe. The specimens vary greatly in size, the wings of the females ranging in length from 9.5 to 13 millimeters. The species is related to *L. solitaria* (Osten Sacken), *L. hudsonica* (Osten Sacken), and *L. fallax* (Johnson), all from eastern North America.

Limonia annulus truncata subsp. nov.

Very similar in general appearance to typical *annulus* (Meigen) of Europe. Gonapophyses of the male hypopygium relatively slender, dilated into a distinct head at apex, this head squarely truncated, densely provided with abundant setæ which are grouped especially at the mesal apical angle. In typical *annulus* the stem of each apophyse is broader, scarcely dilated into a head, apex obliquely truncated, the mesal apical angle with a dense brush of setæ which continue basad for some distance along the mesal face of apophyse.

Habitat.—Japan (Hokkaido).

Holotype, male, Shikotsu, September 24, 1922 (*T. Esaki*).

Allotype, female, Kamiotoineppu, August 23, 1922 (*T. Esaki*).

Paratypes, female, Kamuikotan, August 22, 1922 (*T. Esaki*); male and female, Abashiri, August 30, 1922 (*T. Esaki*); male, Akan, September 3 to 7, 1922 (*T. Esaki*); 1 female, Panketo, September 6, 1922 (*T. Esaki*); male, Teppetsu, September 9, 1922 (*T. Esaki*).

Limonia bifasciata avis (Alexander).

Limnobia avis ALEXANDER, Ann. Ent. Soc. Am. 11 (1918) 444.

The type is from Takuhara, Shinano Province, Honshiu. The race is distinguished from typical *bifasciata* (Schrank) of Europe, chiefly by the considerable increase in the amount of black on the prescutum, and especially on the tips of the femora. In this subspecies, the vertex bears a large black area extending from the posterior angles of the eyes caudad, narrowed to the occiput. The median prescutal stripe is broad and distinct, split medially, but connected narrowly at the anterior end and more broadly just before the suture. The black femoral tips measure more than 1 millimeter in extent. The Formosan *Limonia xanthopteroides* (Riedel) is probably another geographical race of this widespread Palæarctic species.

Hokkaido: Kamiotoineppu, August 25, 1922 (*T. Esaki*); Abashiri, August 30, 1922 (*T. Esaki*); Mount Meakan, altitude 5,300 feet, September 8, 1922 (*T. Esaki*).

Limonia neoindigena sp. nov.

General coloration reddish brown, prescutum with three conspicuous stripes and the extreme lateral margin blackened; anterior pleurites blackened, this also including the fore coxæ; femora pale brown with a black subterminal ring and relatively broad yellow tips; wings yellow, sparsely variegated with brown; r far from tip of R_1.

Male, length, about 11 millimeters; wing, 12.1. Female, length, about 10 millimeters; wing, 10.8 to 11.

Rostrum, palpi, and antennæ black. Head black, very sparsely pruinose. Pronotum black, broadly yellow laterally; in female, pronotum entirely black. Mesonotal prescutum reddish yellow with three conspicuous black stripes, the median stripe not reaching suture, the lateral stripes crossing suture and suffusing the anterolateral portions of the scutal lobes; a large brownish black spot on lateral margins of prescutum opposite anterior ends of prescutal stripes; scutum obscure reddish yellow, centers of each lobe dark brown; scutellum dark brown, indistinctly bisected medially by a capillary pale vitta; mediotergite of postnotum broadly brownish black medially, narrowly pale on lateral margins. Pleura with the anterior sclerites largely shiny black, becoming paler, more brownish, on mesepimeron and pleurotergite of postnotum. Halteres brown, knobs and base of stem yellow in male, knobs infuscated in female. Legs with coxæ yellow, fore coxæ shiny black, except for the extreme apex; trochanters yellow; femora pale brown, tips rather broadly yellow, and with a subequal black subterminal ring; tibiæ and tarsi dark brown, the former paler basally. Wings strongly tinged with yellow, base and costal region brighter; rather sparse brown seams distributed as follows: Origin of Rs; along cord and outer end of cell 1st M_2, and along vein Cu; narrower brown seams along the remaining longitudinal veins and surrounding wing margin, more conspicuous at wing apex; stigma pale brown; veins brown, Sc and prearcular veins brighter. Venation: Sc_2 longer than Sc_1, ending just beyond midlength of Rs, the latter arcuated at origin; r far from tip of R_1; basal deflection of Cu_1 at or before fork of M. Abdomen obscure yellowish brown, sternites brighter, the subterminal segments infuscated. Male hypopygium infuscated; basistyles relatively slender, the mesal face produced into a simple setiferous lobe; a single dististyle, this broad at base, narrowed to apex which bears numerous tiny setæ; dististyle brown except the yellow apical third. Gonapophyses appearing as flattened plates, each with a deep U-shaped notch, the mesal lobe very large. Ædeagus bifid at apex, the ventral face densely set with abundant stout spinulæ.

Habitat.—Japan (Hokkaido).

Holotype, male, Panketo, September 6, 1922 (*T. Esaki*).

Allotype, female, Shikaripetsu, August 25, 1922 (*T. Esaki*).

Paratype, female, Kamiotoineppu, August 25, 1922 (*T. Esaki*).

Limonia karafutonis sp. nov.

Related to *L. tripunctata* (Fabricius); antennæ black, only the basal flagellar segments feebly bicolorous; mesonotal prescutum with a single very broad median stripe; femora yellow, tips broadly blackened, wings tinged with yellow, sparsely variegated with brown; r remote from tip of R_1.

Male, length, 7 millimeters; wing, 8.5 to 9. Female, length, about 8 millimeters; wing, 9.

Rostrum and palpi black, mouth parts a little paler. Antennæ black, the two basal flagellar segments bicolorous, the basal half or less of each obscure yellow. Head grayish black, occiput obscure yellow. Pronotum dark brown, paler laterally. Mesonotal prescutum obscure yellow, with a very broad median black stripe, the lateral margins of sclerite narrowly infuscated to produce small lateral stripes; scutum yellow, lobes conspicuously blackened; scutellum and postnotum less distinctly infuscated. Pleura yellow with a faint brown cloud behind fore coxæ. Halteres obscure yellow, knobs faintly infuscated. Legs with coxæ yellow, fore coxæ infuscated; trochanters obscure yellow; femora yellow, tips broadly blackened; tibiæ brownish yellow, tips narrowly blackened; tarsi dark brown, basitarsi paler at proximal ends. Wings tinged with yellow, base and costal region brighter; sparse brown seams distributed as follows: At origin of Rs, Sc_2, along cord and outer end of cell 1st M_2; more conspicuous clouds at r; behind vein Cu, interrupted before its fork; faint brown clouds in the prearcular region and along vein 2d A; veins dark brown, Sc yellow. Venation; Sc_2 a little longer than Sc_1, ending just before fork of Rs; r from three to four times its length from tip of R_1; basal deflection of Cu_1 at or close to fork of M. Abdominal tergites dark brown, sclerites a little darker posteriorly; basal sternites obscure yellow; hypopygium yellow.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 17, 1922 (*T. Esaki*).

Allotopotype female, July 23, 1922 (*T. Esaki*); at honey bait trap.

Paratopotypes, 5 males and females, July 14 to 18, 1922 (*T. Esaki*).

Limonia episema sp. nov.

Related to *L. trivittata* (Schummel); general coloration obscure yellow; basal antennal segments obscure yellow; mesonotal prescutum with three conspicuous brownish black stripes; femora yellow, tips blackened, with one or two pale brown subterminal rings; wings pale yellow, very sparsely variegated with brown; r encircled by a pale brown ring; abdomen brown, the caudal margins of segments obscure yellow.

Female, length, 9 to 11 millimeters; wing, 10 to 12.

Rostrum and palpi dark brown. Antennæ with scape and basal two flagellar segments obscure yellow; intermediate flagellar segments feebly bicolorous, dark brown, base of each obscure yellow; terminal segments uniformly dark brown. Head dark gray. Pronotum black, the lateral margins obscure yellow. Mesonotal prescutum obscure ferruginous with three very conspicuous black stripes, the median stripe not reaching suture, its caudal end feebly bifid; scutal lobes conspicuously infuscated; the remainder of mesonotum obscure ferruginous. Pleura shiny ferruginous, with an ill-defined brown spot on episternum; ventral portions of sternopleura infuscated. Halteres pale brown, knobs infuscated, base of stem yellow. Legs with coxæ reddish, faintly infuscated; trochanters obscure yellow; femora yellow, tips rather broadly blackened; an ill-defined dusky ring near two-thirds the length of segment, preceded by a distinct yellowish subterminal annulus; some individuals show, in addition, a third cloud near midlength of segment; tibiæ pale brown, tips darker; tarsi dark brown. Wings pale yellow, base and costal region brighter; a very sparse brown pattern, distributed as follows: At origin of Rs; Sc_2; and a seam along vein Cu; cord and outer end of cell 1st M_2 scarcely seamed with darker; stigma an eyelike spot, r being unseamed; veins dark brown, brighter in the yellow areas. Venation: Sc_1 ending just beyond midlength of Rs; Sc_1 a little longer than Sc_2; r about twice its length from tip of R_1; basal deflection of Cu_1 variable in position, from before to beyond fork of M. Abdomen brown, the caudal margins of segments obscure yellow; sternites obscure yellow, the caudal margins brighter; basal lateral angles of sternites infuscated.

Habitat.—Japan (Saghalien).

Holotype, female, Toyohara, July 23, 1922 (*T. Esaki*); at honey bait trap.

Paratopotypes, 3 females, July 20 to 23, 1922 (*T. Esaki*).

Limonia plutonis sp. nov.

General coloration black, sparsely pruinose; halteres yellow, the knobs infuscated; legs slender, black, the femoral bases yellow; wings yellow with a sparse brown pattern.

Female, length, 10 millimeters; wing, 14.5.

Rostrum and palpi black. Antennæ with the basal segment black, the second segment brown; flagellum broken. Head dark gray; vertex between eyes reduced to a linear strip, the anterior end of which is light silvery. Pronotum black, very sparsely dusted with gray. Mesonotum black, the prescutal interspaces sparsely pruinose, stripes shiny black; scutum, scutellum, and postnotum clear gray pruinose. Pleura black, sparsely pruinose. Halteres yellow, knobs infuscated. Legs with coxæ black; trochanters light yellow; remainder of legs black, the femoral bases yellow; legs relatively long and slender. Wings tinged with yellow, base and cells C and Sc bright yellow; a conspicuous brown stigma, extending basad in cell 1st R_1 to opposite fork of Rs; a small brown cloud at origin of Rs; conspicuous brown seams along cord and outer end of cell 1st M_2; wing tip conspicuously dark brown, broadest in cell R_3; a broad and conspicuous brown seam along vein Cu, more extensive in cell M; veins dark brown, yellowish in the flavous areas. Venation: Sc_1 ending just before fork of Rs, Sc_2 some distance from tip, Sc_1 alone about one-half longer than r; r about twice its length from tip of R_1; cell 1st M_2 long and narrow, gently widened distally, longer than the veins issuing from it; basal deflection of Cu_1 a short distance beyond fork of M. Abdomen dark brownish black. Valves of ovipositor reddish horn color; valves obliquely truncated at tips, the sternal valves more strongly so.

Habitat.—Japan (Saghalien).

Holotype, female, Toyohara, July 13, 1922 (*T. Esaki*).

Limonia monacantha sp. nov.

General coloration dark brown, wings tinged with brown and with a sparse darker brown pattern; male hypopygium with the ventral dististyle bearing on its mesal face a slender, pale, curved appendage and a single blackened spine.

Male, length, about 4.8 millimeters; wing, 6.3.

Rostrum and palpi very small, black. Antennæ black throughout, the basal flagellar segments subglobular, the terminal segments gradually more elongate; segments very short-pedicellate. Head black. Pronotum black. Mesonotum and pleura dark brown, without distinct stripes. Halteres dark brown. Legs brown throughout. Wings distinctly tinged with brown and with a sparse, darker brown pattern, distributed as follows: A large cloud at origin of Rs; a small cloud at tip of Sc; a large, circular stigmal blotch; conspicuous brown seams along cord and outer end of cell 1st M_2; veins dark brown. Venation: Sc long, ending beyond midlength of Rs, Sc_2 at tip of Sc_1; Rs long, angulated and feebly spurred at origin; r about one and one-half times its length from tip of R_1 which is curved strongly into costa beyond it, inner ends of cells R_3 and 1st M_2 far basad of cell R_5; basal deflection of Cu_1 just beyond fork of M. Abdomen dark brown, the basal sternites a little paler. Male hypopygium (Plate 1, fig. 8) with basistyle relatively stout, the mesal face produced into a conspicuous lobe which bears near its apex on the caudal end a small tubercle bearing two or three long, powerful setæ. Ventral dististyle fleshy, the mesal face at base produced mesad into a long, slender, gently curved appendage that is only a little shorter than the dorsal dististyle; the inner or cephalic margin of this bears five or six setiferous tubercles that become more distant from one another toward apex; apex with a stouter seta; at base of this appendage and inserted just beyond it on dististyle itself is a powerful spine, curved at base, the long, straight apex heavily blackened. Dorsal dististyle straight basally, the apical third narrowed and bent almost at a right angle. Gonapophyses appearing as flattened plates, the mesal apical angle produced caudad into a short, gently curved hook.

Habitat.—Japan (Hokkaido).

Holotype, male, Teppetsu, September 9, 1922 (*T. Esaki*).

Limonia basispina sp. nov.

General coloration dark brown, the prescutal stripes pale reddish brown; wings tinged with brown, with a conspicuous dark brown pattern; male hypopygium with the mesal face of the ventral dististyle produced into a conspicuous chitinized lobe that bears a long, straight spine at one-third its length.

Male, length, 6.2 to 7 millimeters; wing, 7.8 to 8.6. Female, length, 5 to 6.2 millimeters; wing, 6.5 to 7.2.

Rostrum and palpi black. Antennæ black throughout, the basal flagellar segments globular, the terminal segments passing through oval to cylindrical, segments with a short basal pedicel. Anterior part of vertex silvery white; remainder of head dark brown. Pronotum pale ocherous brown medially, the lateral margins a little darker. Mesonotal prescutum dark brown with three conspicuous, pale reddish brown stripes; scutum pale medially, lobes reddish brown with the mesal edge dark brown; scutellum and postnotum dark brown, the posterior third of latter more reddish. Pleura dark brown, indistinctly variegated with paler brown. Halteres dark brown, the extreme base of stem obscure yellow. Legs with coxæ ocherous, the extreme bases brown; trochanters yellow; femora pale brownish yellow, faintly darkened to tips; remainder of legs dark brown; claws simple. Wings with a strong brown tinge and with a conspicuous dark brown pattern, distributed as broad clouds at origin of Rs, tip of Sc, fork of Rs, stigma, cord, outer end of cell 1st M_2, and, in cases, a spot at tip of R that is distinct from stigmal spot; wing tip distinctly darkened; veins dark brown. Venation: Sc long, Sc_2 at tip of Sc_1, ending from two-thirds to three-fourths the length of Rs; Rs strongly angulated and spurred at origin; r unusually variable in position, in cases more than twice its length from tip of R_1, in other examples less than its length from tip; inner end of cell R_3 lying slightly basad of 1st M_2 and far basad of R_5; cell 1st M_2 closed; m shorter, usually much shorter, than the more or less arcuate outer deflection of M_3; basal deflection of Cu_1 close to fork of M. Abdomen dark brown, the basal segments a little paler. Male hypopygium (Plate 1, fig. 7) with basistyle relatively stout, the mesal face produced into a conspicuous, pale, chitinized lobe that bears at its apex on the caudal end a conspicuous tubercle bearing about six stout setæ. Ventral dististyle fleshy, the mesal face at base produced mesad into a conspicuous, cylindrical arm which bears near one-third its length a powerful, straight spine; the apical two-thirds gently curved, bearing at its tip a group of setæ. Dorsal dististyle gently curved to the acute tip. Gonapophyses appearing as flattened plates, the mesal apical angle produced caudad into a gently curved hook, with a small chitinized tubercle laterad of its base.

Habitat.—Japan (Hokkaido).

Holotype, male, Panketo, September 6, 1922 (*T. Esaki*).

Allotype, female, Kamuikotan, August 22, 1922 (*T. Esaki*).

Paratypes, 1 male, Kamiokoppe, August 27, 1922 (*T. Esaki*); 1 female, Kamiotoineppu, August 23, 1922 (*T. Esaki*).

Limonia subnubeculosa (Alexander).

Limnobia subnubeculosa ALEXANDER, Trans. Am. Ent. Soc. 46 (1920) 5, 6.

Doctor Esaki's material includes the following records:

Saghalien: Toyohara, July 23, 1922, at honey bait trap; Odasam, August 5, 1922.

The species was described from Honshiu and has not yet been discovered in Hokkaido.

Limonia neonebulosa nom. nov.

Dicranomyia nebulosa ALEXANDER, Can. Ent. 45 (1913) 203 to 205, preoccupied by *Limonia nebulosa* (Zetterstedt), Ins. Lapponica, Diptera (1838) 836.

The collection includes the following records, collected by Doctor Esaki:

Saghalien: Toyohara, July 23, 1922, at honey bait trap. Hokkaido: Sapporo, August 17, 1922; Jozankei, August 19, 1922; Kamuikotan, August 22, 1922; Kamiotoineppu, August 23 to 26, 1922; Shikaripetsu, August 26, 1922; Kamiokoppe, August 27, 1922.

The fly had been known hitherto only from stations in Honshiu. It varies considerably in size, males showing wing lengths of from 4.7 to 8 millimeters.

Limonia machidai (Alexander).

Dicranomyia machidai ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 113.

This little fly was described from specimens taken in the vicinity of Tokyo, Honshiu. It seems to be more correctly referable to *Limonia* than to *Dicranomyia.* Esaki's collection adds the following records:

Saghalien: Toyohara, July 13 to 20, 1922. Hokkaido: Sapporo, August 17, 18, 1922; Kamuikotan, August 22, 1922; Kamiotoineppu, August 23, 24, 1922; Abashiri, August 30, 1922.

Limonia angustistria sp. nov.

General coloration light brownish yellow, the prescutum with a χ-shaped brown median stripe; pleura obscure yellow with a narrow but very conspicuous dark brown longitudinal stripe; wings subhyaline, stigma darker brown; Rs angulated and spurred at origin; r at tip of R_1.

Male, length, 4 to 4.8 millimeters; wing, 5.8 to 6.2. Female, length, 4.8 to 5 millimeters; wing, 6.2 to 6.8.

Rostrum and palpi brown. Antennæ black throughout, the flagellar segments subglobular, passing into oval toward end of organ. Head dark brown. Mesonotal prescutum light brownish yellow, the median stripe darker brown, beyond midlength of sclerite becoming obliterated but at this point becoming confluent with the lateral stripes, thus appearing χ-shaped, the arms inclosing a pale triangle at suture; lateral margins of segments faintly infuscated; remainder of mesonotum light brownish yellow, the scutal lobes dark brown. Pleura obscure yellow with a narrow but very conspicuous dark brown longitudinal stripe extending from propleura to base of abdomen, passing beneath root of halteres; sternopleura faintly darkened between fore and middle coxæ. Halteres pale brown, the knobs a little darker, base of stem narrowly brightened. Legs with coxæ and trochanters yellow; femora obscure yellow; tibiæ and tarsi pale brown, the terminal segments of latter darkened. Wings subhyaline, stigma pale brown, circular to oval in outline, veins dark brown. Venation: Sc long, Sc_1 ending from two-thirds to three-fourths the length of Rs, Sc_2 close to its tip; Rs angulated and feebly spurred at origin; r at tip of R_1; inner end of cell R_3 far distad of inner ends of cells R_5 and 1st M_2; m a little shorter than outer deflection of M_3; basal deflection of Cu_1 near fork of M; Cu_2 and basal deflection of Cu_1 subequal. Abdominal tergites dark brown, the caudal margins of segments narrowly yellowish; basal sternites paler but similarly marked; hypopygium and genital segment of female obscure yellow. Male hypopygium (Plate 1, fig. 6) with each basistyle cylindrical, the mesal face with a moderately large setiferous lobe; dististyles two, one fleshy throughout, enlarged basally, narrowed to the slender apex, the mesal or cephalic face with numerous large setæ which become modified into powerful yellow spines on basal half of style to form a comb; the other dististyle is complicated in structure, consisting of two chitinized arms and a bilobed fleshy outer lobe that is provided with long setæ; the longest chitinized lobe produced into a slender beak, on outer margin before tip with a few powerful bristles; second arm a small, ovate blackened scale at base of the larger one. Gonapophyses relatively slender. Ædeagus bilobed at apex.

Habitat.—Japan (Hokkaido).

Holotype, male, Kamuikotan, August 22, 1922 (*T. Esaki*).

Allotype, female, Kamiokoppe, August 27, 1922 (*T. Esaki*).

Paratopotypes, 11 males and females; paratypes, 1 male, 1 female, with the allotype; 2 males and females, Jozankei, August 19, 1922 (*T. Esaki*); 2 males, Kamiotoineppu, August 24, 1922 (*T. Esaki*); 1 male, Nayoro, August 26, 1922 (*T. Esaki*).

Limonia angustistria bears a considerable resemblance to *L. machidai* Alexander in size and general coloration but is readily separated by the details of color and the structure of the hypopygium.

Limonia amabilis sp. nov.

General coloration light yellow; head and antennæ black; mesonotal prescutum with a single, narrow, dark brown, median stripe; legs black, the femora with an extensive, obscure yellow ring before tips; wings light yellow with a sparse brown pattern that includes a large stigma; Rs strongly arcuated; caudal margins of abdominal segments narrowly darkened.

Female, length, 8.5 to 9 millimeters; wing, 7 to 9.

Rostrum and palpi black. Antennæ black, the apex of first and the entire second scapal segment obscure yellow. Head dark brownish black, sparsely pruinose. Pronotum dark brown, narrowly yellowish laterally. Mesonotum light yellow, prescutum with a single narrow dark brown stripe that is narrowed behind and becomes obsolete before suture. Pleura uniformly yellow. Halteres yellow, the knobs dark brown. Legs with coxæ and trochanters yellow; femora brownish black, the extreme tips very narrowly obscure yellow; an extensive obscure yellow annulus before the slightly less extensive black tips; remainder of legs black. Wings light yellow with a sparse brown pattern; stigma large, dark brown; cord and outer end of cell 1st M_2 narrowly seamed with dark brown; a small brown cloud near midlength of cell R, this sometimes barely evident; veins dark brown. Venation: Rs short and very strongly arcuated; Sc_2 at tip of Sc_1, ending near two-thirds the length of sector; r removed from tip of R_1 to at least two times its length; basal deflection of Cu_1 near fork of M. Abdomen obscure yellow, the caudal margins of segments narrowly darkened. Ovipositor with the valves relatively short and stout, especially the ventral valves.

Habitat.—Japan (Hokkaido).

Holotype, female, Kamiotoineppu, August 25, 1922 (*T. Esaki*).

Paratopotypes, 4 females, August 23 to 25, 1922; 1 female, Kamuikotan, August 22, 1922 (*T. Esaki*); 1 female, Jozankei, August 19, 1922 (*T. Esaki*).

Genus **LIBNOTES** Westwood

Libnotes WESTWOOD, Trans. Ent. Soc. London (1876) 505.

The genus *Libnotes* is a chiefly oriental group which sends two species into Hokkaido.

Libnotes longistigma Alexander.

Libnotes longistigma ALEXANDER, Insec. Inscit. Menst. 9 (1921) 180, 181.

Specimens from Jozankei, August 19, 1922, and Kamiotoineppu, August 23, 24, 1922, were taken by Esaki. The species was described from Koto-sho Islands, near Formosa, and is close to *L. strigivena* (Walker).

Libnotes nohirai Alexander.

Libnotes nohirai ALEXANDER, Ann. Ent. Soc. Am. 11 (1918) 445.

Esaki's material includes specimens from the following localities in Hokkaido:

Akan, September 3, 1922; Panketo, September 6, 1922; Shikotsu, September 24, 1922.

The type locality is Iwate Province, northern Honshiu.

Genus **ELLIPTERA** Schiner

Elliptera SCHINER, Wien. Ent. Monatschr. 7 (1863) 222.

The genus *Elliptera* includes six described species, two from Europe, three from western North America, and a single small species from eastern North America (southern Illinois to Tennessee). The discovery of an undescribed species in Japan was therefore to be expected.

Elliptera zipanguensis sp. nov.

General coloration brownish black; wings distinctly tinged with brown; r preserved; basal deflection of R_{4+5} only a little longer than r-m; cell 1st M_2 open by the atrophy of the outer deflection of M_3.

Female, length, 5.8 millimeters; wing, 8.4.

Rostrum and palpi brownish black. Antennæ black throughout, the flagellar segments with a dense white pubescence. Head black, anterior part of vertex sparsely pruinose; vertex between eyes broad, with a compressed median ridge immediately behind antennal bases. Mesonotum shiny brownish black, the lateral margins of prescutum paler. Pleura brownish black with a longitudinal gray stripe across dorsal margin of sternopleura; dorsopleural membrane dark brown. Halteres dark brown, the base of stem narrowly yellowish. Legs with coxæ greenish testaceous, the fore coxæ infuscated basally; trochanters greenish brown; remainder of legs darker brown, the femoral bases paler. Wings distinctly tinged with brown; stigma lacking; veins darker brown. Venation: Sc_1 long, ending a distance before base of deflection of R_{4+5} that is subequal to the length of latter, Sc_2 immediately before origin of long Rs, the latter longer than R_{2+3} alone; the apparent r distinctly preserved, lying beyond fork of Rs a distance about equal to basal deflection of R_{4+5}; inner ends of cells R_3, R_5 and 1st M_2 in approximate alignment; deflection of R_{4+5} only about one-third longer than r-m and nearly straight; basal deflection of M_{1+2}

arcuated; cell 2nd M_2 approximately as long as its petiole; basal deflection of Cu_1 beyond fork of M. Abdomen dark brown, the sternites obscure yellow, only the subterminal segments infuscated. Ovipositor with the valves horn-colored, the tergal valves short, very strongly upcurved.

Habitat.—Japan (Hokkaido).

Holotype, female, Shikotsu, September 24, 1922 (*T. Esaki*).

Elliptera zipanguensis is a very distinct species, remarkable in the retention of the *apparent* radial cross vein, which as was indicated by me in earlier papers is, in the Tipulidæ, almost certainly the basal deflection of vein R_2. The true r is thus presumably lacking in the Diptera, its occurrence in *Dicranota, Rhaphidolabina,* and *Polyangaeus* being due to a supernumerary cross vein that has persisted in this position in cell R_1. The present species is further characterized by the very elongate Sc and Rs and the shortened, subtransverse basal deflection of R_{4+5}. The specific name is derived from Zipangu, Marco Polo's designation for the Empire of the Rising Sun.

Genus **HELIUS** St. Fargeau and Serville

Helius ST. FARGEAU and SERVILLE, Encycl. Meth. Ins. 10, Index (1828) 831.

Rhamphidia MEIGEN, Syst. Beschr. 6 (1830) 281.

Helius (Helius) tenuirostris sp. nov.

General coloration shiny yellow, the prescutum with a median dark brown stripe; rostrum long and slender, equal in length to thorax; wings tinged with gray, the costal region yellowish; wing apex infuscated; abdominal tergites yellow, ringed with brown.

Male, length (excluding rostrum), 7 millimeters; wing, 7 to 7.5; rostrum alone, about 1.8 to 2. Female, length, 7.6 to 8 millimeters; wing, 7 to 7.2; rostrum alone, about 1.9.

Rostrum unusually long and slender, about as long as thorax alone, rostrum and palpi black. Antennæ very short, with conspicuous verticils, brown, the second segment obscure yellow. Head brownish gray; vertex between eyes very narrow. Pronotum obscure yellow, infuscated medially. Mesonotal prescutum shiny reddish yellow, the humeral region clearer yellow; a shiny brown median stripe; scutal lobes dark brown, the median area pale; scutellum brownish black; postnotum brown, passing into reddish yellow laterally. Pleura reddish yellow. Halteres pale brownish yellow, brighter at base.

Legs with coxæ and trochanters reddish yellow; femora obscure yellow, the tips narrowly blackened; tibiæ pale brown, tips very narrowly blackened; tarsi black. Wings tinged with gray; cells C and Sc more yellowish; stigma oval, brown; wing tip distinctly infuscated; veins brown, those in costal region yellowish. Venation: Sc_2 ending just before fork of Rs; r-m shorter than deflection of R_{4+5}; basal deflection of Cu_1 beyond fork of M, in some cases the distance equal to approximately one-half the deflection. Abdominal tergites obscure yellow, the basal half or more of segments infuscated; sternites uniformly yellow; a subterminal black ring on segments 7 and 8; hypopygium shiny reddish yellow. In the female, the abdominal tergites are dark brown. Ovipositor with the tergal valves very long and slender, straight.

Habitat.—Japan (Hokkaido and Honshiu).

Holotype, male, Mount Minomo, Settsu-no-kuni, Honshiu, June 22, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotypes, 3 males; paratypes, 1 male, 1 female, Jozankei, Hokkaido, August 19, 1922 (*T. Esaki*).

Genus DICRANOPTYCHA Osten Sacken

Dicranoptycha OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 217.

Dicranoptycha venosa sp. nov.

General coloration gray; halteres yellow; legs black, femoral bases yellow, narrowest on forelegs, broadest on posterior femora; wings brownish yellow, base and costal region clear yellow; longitudinal veins seamed with brown; r some distance from tip of R_1.

Male, length, 8.5 to 10 millimeters; wing, 10 to 10.5. Female, length, 10 millimeters; wing, 11.

Rostrum and palpi black. Antennæ with first segment of scape black; second segment obscure yellow; flagellum brownish black, the proximal segments a little paler on basal half. Head gray. Mesonotum gray, prescutum with four rather ill-defined dark brown stripes. Pleura dark gray, indistinctly variegated with black. Halteres yellow. Legs with coxæ and trochanters obscure yellow; fore femora black with about the basal third yellow; other femora obscure yellow with about the distal third or less black, this a little more extensive on middle legs; remainder of legs brownish black. Wings brownish yellow, base and cells C and Sc clearer yellow; longitudinal veins seamed with darker, this especially conspicuous on veins Cu and Cu_2; veins black, yellow in the flavous costal areas, including stigma. Venation: Sc_1 ending opposite midlength the deflection of R_{4+5}, Sc_2 at its tip; R_1 beyond r equal to or subequal to basal deflection of R_{4+5}; Rs longer than cell 1st M_2; Rs and R_{2+3} run very close to R_1; m short; basal deflection of Cu_1 from one-third to one-half its length beyond the fork of M. Abdomen dark brown.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Shikaripetsu, Hokkaido, August 26, 1922 (*T. Esaki*).

Allotype, female, Ponkikin, Hokkaido, September 2, 1922 (*T. Esaki*).

Paratypes, 3 males, Shikotsu, Hokkaido, September 24, 1922 (*T. Esaki*); 1 female, Shimizu, Saghalien, July 27, 1922 (*T. Esaki*); 1 male, Maoka, Saghalien, July 28, 1922 (*T. Esaki*).

Genus **ANTOCHA** Osten Sacken

Antocha OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 219.

No fewer than six species of *Antocha* were found in the present collection. The genus appears to be an ancient one that elsewhere in the world persists only as scattered species living under favorable conditions, chiefly in mountainous and hilly sections of the Holarctic Region. Hitherto not more than two species had been found in any one given region and the discovery of six species occurring in the vicinity of Sapporo, Hokkaido, was very surprising. The early stages of members of the genus, insofar as they are known, are spent in running water, and it seems probable that the numerous mountain streams of Japan have done much to favor the development and preservation of species of this genus. The Japanese species of the genus may be separated by means of the accompanying key.

A Key to the Japanese Species of the Genus Antocha.

[Males only.]

1. Legs very long and relatively stout, densely clothed with conspicuous erect setæ; in the male, opposable tubercles at tip of tibia and base of basitarsus; tarsi very short; in the female, tergal valves of ovipositor very short and stout, heavily chitinized, the ventral margin serrate. (Subgenus *Proantocha* Alexander.) .... 2.

Legs relatively long and slender, clothed with inconspicuous, appressed setæ; in the male, legs unarmed and tarsi of normal length; in the female, all valves of ovipositor slender, their margins smooth. (Subgenus *Antocha* Osten Sacken.) .... 3.

2. Large species (wing of male over 12 millimeters); posterior tarsi very short, less than one-fourth the length of tibiæ. (Honshiu.)
A. (P.) spinifer Alex.

Smaller species (wing of male less than 8 millimeters); posterior tarsi more than one-fourth the length of tibiæ. (Hokkaido.)
A. (P.) serricauda sp. nov.

3. Sc long, Sc_1 ending opposite fork of Rs or very nearly so .... 4.

Sc shorter, Sc_1 ending some distance before fork of Rs .... 5.

4. Wings with stigma distinct, veins dark; male hypopygium with the glabrous dististyle heavily chitinized, apex produced into a slender point; ædeagus deflexed at tip. (Honshiu and Hokkaido.)
A. (A.) satsuma Alex.

Wings with stigma lacking, veins pale; male hypopygium with the glabrous dististyle weakly chitinized, apex feebly notched; aedeagus straight. (Honshiu and Hokkaido.) .... **A. (A.) bifida sp. nov.**

5. Basistyle of male hypopygium without a setiferous lobe on mesal face at base; glabrous dististyle chitinized, gradually narrowed to an acute point; setiferous dististyle broadly dilated at base. (Hokkaido.)
A. (A.) dilatata sp. nov.

Basistyle of male hypopygium with a small setiferous lobe on mesal face at base; glabrous dististyle feebly chitinized; setiferous dististyle not dilated at base .... 6.

6. Wings strongly tinged with brown; r-m near one-third the length of cell 1st M_2; legs relatively slender; male hypopygium with the glabrous dististyle slender, tapering to the subacute tip; gonapophyses straight. (Hokkaido.) .... **A. (A.) brevinervis sp. nov.**

Wings nearly hyaline; r-m immediately before midlength of cell 1st M_2; legs conspicuous, long and relatively stout; male hypopygium with the glabrous dististyle broad, apex feebly bifid; gonapophyses sinuous. (Hokkaido.) .... **A. (A.) brevistyla sp. nov.**

Antocha (Proantocha) serricauda sp. nov.

Size medium (wing under 8 millimeters); general coloration yellow; tarsi of male more than one-fourth the length of tibiæ.

Male, length, 5 to 6 millimeters; wing, 5.8 to 7.5. Female, length, 5 to 6 millimeters; wing, 6 to 7.5 millimeters.

Rostrum and palpi obscure yellow. Antennæ pale brown, the basal segment more yellowish. Head pale yellowish brown, sparsely pruinose. Thorax yellow, prescutum and scutal lobes a trifle more fulvous. Halteres pale, knobs only slightly darker. Legs with coxæ and trochanters yellow; remainder of legs yellowish testaceous, the terminal segments dark; legs conspicuously hairy, as in this group. Wings yellowish subhyaline; veins pale brownish yellow. Venation: r a little more than its length from tip of R_1; basal deflection of Cu_1 approximately one-third its length, or less, before fork of M. Abdomen with tergites reddish brown, the caudal and lateral margins of segments clearer yellow; sternites obscure yellow. Male hypopygium (Plate 2, fig. 9) with the ninth tergite bearing two rounded lobes, these separated by a relatively broad U-shaped notch. Basistyle relatively slender, evenly covered with a few long setæ, these more numerous and more delicate on the mesal face; mesal face at base produced into a large setiferous lobe. Dististyles two, the glabrous style a broad, paddle-like blade with a conspicuous, erect marginal tooth; setiferous style clavate, densely setiferous. Gonapophyses straight, blunt at tips. Ædeagus subtended on either side by a large flaring blade. Ovipositor with the tergal valves short and very stout, heavily chitinized, the ventral edge with about a dozen teeth, the outer ones smaller, the basal ones more obtuse; a dense pencil of yellow setæ on either side of tergite, these directed caudad.

Habitat.—Japan (Hokkaido).

Holotype, male, Jozankei, August 20, 1922 (*T. Esaki*).

Allotype, female, Sapporo, June 25, 1921 (*S. Kuwayama*). No. 105.

Paratopotypes, 13 males and females, August 19, 1922; paratype, 1 female, Shikaripetsu, August 26, 1922 (*T. Esaki*).

Antocha (Antocha) satsuma Alexander.

Antocha satsuma ALEXANDER, Ann. Ent. Soc. Am. 12 (1919) 332.

This species was described from Honshiu. The following specimens are in the present collection from Hokkaido:

Sapporo, August 17, 1922; Jozankei, August 19, 1922; Kamuikotan, August 22, 23, 1922; Kamiotoineppu, August 24 to 26, 1922; Kamiokoppe, August 27, 1922 (*T. Esaki*).

The male hypopygium is figured on Plate 2, fig. 13.

Antocha (Antocha) bifida sp. nov.

General coloration pale ocherous, with three pale brown stripes; basal antennal segments pale, the terminal segments darkened; wings subhyaline, stigma lacking, veins pale; Sc long; male hypopygium with the ninth tergite having a conspicuous lateral tooth on either side; glabrous dististyle weakly bifid at apex.

Male, length, 4.2 to 4.8 millimeters; wing, 5.3 to 5.6. Female, length, 5.5 millimeters; wing, 6.5.

Rostrum pale, palpi light brown, the basal segment pale. Antennæ with scape pale, the basal flagellar segments pale, at least basally; terminal segments oval, passing into uniform dark brown. Head dark gray. Mesonotal prescutum pale ocherous, with three pale brown stripes, the broad median stripe indistinctly split by a pale vitta; scutum brown, only the median area a little paler; scutellum and postnotum pale, the latter darker apically. Pleura reddish brown, very slightly pruinose. Halteres pale, knobs feebly darkened. Legs with coxæ and trochanters yellow; remainder of legs obscure yellow, the terminal tarsal segments darkening into brown. Wings subhyaline, stigma lacking or barely indicated; veins pale brown, those in the vicinity of stigma more yellowish. Venation: Sc long, Sc_1 ending immediately before or opposite fork of Rs; r faint, in alignment with r-m, one and one-half times its length from tip of R_1; veins R_{2+3} and R_{4+5} strongly divergent at base, R_{2+3} being subperpendicular to end of Rs; basal deflection of Cu_1 at or before fork of M. Distribution of macrotrichiæ differing from the related *A. javanensis* Alexander; none at extreme tip of R_{2+3}; macrotrichiæ on R_{4+5} including the distal two-thirds to three-fourths of veins; distal sections of veins M_{1+2} and M_3 with macrotrichiæ almost to their bases; Cu_1 with more or fewer macrotrichiæ at tip. In *A. javanensis* there are two or three macrotrichiæ at the distal end of vein R_{2+3}; those on R_{4+5}, M_{1+2} and M_3 virtually confined to the outer halves of the sections; none on distal section of Cu_1. Abdominal tergites dark brown, the caudal margins narrowly pale; basal sternites yellow, the subterminal sternites passing into brown, with pale caudal margins; hypopygium yellow. Male hypopygium (Plate 2, fig. 10) with the ninth tergite bidentate, a conspicuous lateral tooth on either side, widely separated by a setiferous U-shaped notch. Basistyles relatively slender, distribution of setæ even, no tubercle on mesal face at base. Dististyles two, the glabrous one rather strongly chinitized throughout its length, curved, apex weakly notched; setiferous style subequal to last in length, nearly uniform in width throughout its length. Gonapophyses relatively short, straight, tips subacute. Proctiger conspicuous, its caudal margin oval in outline.

Habitat.—Japan (Honshiu and Hokkaido).

Holotype, male, Jozankei, Hokkaido, August 19, 1922 (*T. Esaki*).

Allotype, female, Gifu, Mino Province, Honshiu, October 10, 1920 (*K. Takeuchi*).

Paratopotypes, 2 males; paratypes, 1 male, Sapporo, August 17, 1922 (*T. Esaki*); 4 males and females, Kamiotoineppu, August 23, 24, 1922 (*T. Esaki*); 20 males and females, with the allotype, October 1 to 10, 1920.

In some cases, gray individuals are found, as is common in the genus *Antocha.*

Antocha (Antocha) dilatata sp. nov.

General coloration gray, prescutum with three brown stripes; wings subhyaline, stigma lacking, veins pale; Sc short; male hypopygium with basistyles lacking a setiferous lobe on mesal face at base; glabrous dististyle terminating in a chitinized point; setiferous style conspicuously dilated at base.

Male, length, 4.5 to 5 millimeters; wing, 5 to 5.5. Female, length, about 6 millimeters; wing, 6.5 to 7.

Rostrum pale brown, in some specimens brightening into yellow; mouth parts brown. Antennæ with the basal segments usually pale, the terminal segments passing into brown. Head dark brown, genæ light gray pruinose. Mesonotal prescutum dull gray with three brown stripes; scutum gray, lobes with brown centers; scutellum and postnotum light gray. Pleura gray. Halteres pale. Legs with coxæ and trochanters light yellow, fore coxæ gray pruinose at base; fore femora yellowish, the other femora brownish yellow; remainder of legs brown, the terminal tarsal segments dark brown. Wings subhyaline or whitish subhyaline, stigma lacking; veins pale and very indistinct. Venation: Sc short, Sc_1 ending some distance before fork of Rs; cell Sc_1 chitinized; r-m at from one-third to one-fourth the length of cell 1st M_2, the basal section of M_{1+2} short and straight; basal deflection of Cu_1 from one-third to one-half its length before fork of M. Abdomen dark brown, sternites pale, brownish yellow; hypopygial basistyles conspicuously yellow. Male hypopygium (Plate 2, fig. 14) with the basistyles relatively long but stout, setæ uniformly distributed; no setiferous lobe on mesal face at base. Dististyles two, the glabrous style chitinized, especially apically, broader at base, tapering gradually to the gently curved, subacute apex; setiferous style conspicuously dilated on inner margin at base. Gonapophyses short, appearing as rather broad flattened blades. Ædeagus slender, sides at base weakly setiferous.

Habitat.—Japan (Hokkaido).

Holotype, male, Kamiotoineppu, August 24, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotypes, 13 males and females, August 24, 25, 1922 (some taken in copula); paratypes, 6 males and females, Jozankei, August 19, 1922; 1 female, Lake of Akan, September 7, 1922; 1 female, Panketo, September 6, 1922 (*T. Esaki*).

Antocha (Antocha) brevinervis sp. nov.

General coloration gray, prescutum with three dark brown stripes; wings tinged with brown; vein Sc short; male hypopygium with a setiferous lobe on mesal face of each basistyle; gonapophyses short.

Male, length, 4 to 5.2 millimeters; wing, 4.3 to 6.4. Female, length, 5 millimeters; wing, 4.8.

Rostrum and palpi dark brown. Antennæ dark brown. Head brown, sparsely pruinose. Mesonotum grayish brown, prescutum with three dark brown stripes, the lateral margins clearer gray; remainder of mesonotum clearer gray, the scutal lobes infuscated. Pleura dark grayish brown. Halteres dark brown, the extreme base of stem yellow. Legs with coxæ dark brown, sparsely pruinose; trochanters dark brown, the fore trochanters brighter; remainder of legs dark brown, the posterior legs uniformly paler; setæ of legs short, appressed. Wings tinged with brown; stigma elongate, pale brown; veins dark brown. Venation: Sc short, Sc_1 ending some distance before end of Rs; the part of r within stigma faint; basal deflection of Cu_1 only a short distance before fork of M. Abdomen dark brown, pruinose. Male hypopygium (Plate 2, fig. 12) with basistyles on mesal face at base with a small obtuse tubercle, densely set with setæ; lateral face of each basistyle glabrous or nearly so. Glabrous dististyle uniformly colored throughout, apex subacute. Gonapophyses shorter, stouter and straighter than in *A. satsuma.*

Habitat.—Japan (Hokkaido).

Holotype, male, Jozankei, August 19, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotype, 1 male; paratypes, 1 male, Lake of Akan, September 4, 1922 (*T. Esaki*), 1 male, in poor condition, Sapporo, June 25, 1921 (*S. Kuwayama*), No. 102.

The Jozankei specimens are very small (the minimum measurements given) but undoubtedly refer to this species.

Antocha (Antocha) brevistyla sp. nov.

Size large (wing of male over 7 millimeters); general color ocherous, pronotum and prescutum darker medially; legs dark brown; wings with Sc short; male hypopygium with dististyles relatively short, the glabrous style dilated into a blade that is feebly notched at apex.

Male, length, about 5.3 millimeters; wing, 7.2.

Rostrum ocherous, palpi black. Antennæ dark brown throughout. Head dark, silvery gray pruinose on anterior part of vertex. Pronotum ocherous, broadly dark brown medially. Mesonotal prescutum reddish brown, darker brown medially; lateral stripes obliterated; scutum and scutellum pale brown; postnotum pale brown, darker posteriorly. Pleura pale, sternopleura infuscated. Halteres pale, knobs infuscated. Legs with coxæ pale, the outer faces darkened; trochanters pale, dark brown apically; remainder of legs dark brownish black, the femoral bases a little paler; legs relatively stout, but elongate; claws with a long, slender, basal spine. Wings subhyaline; stigma barely indicated; veins pale brown. Venation: Sc ending some distance before fork of Rs, as in *A. brevinervis,* costa beyond this fusion slightly incrassated and apparently filling cell Sc_1; r very faint; r-m just before midlength of cell 1st M_2, the basal section arcuate, the distal section straight; basal deflection of Cu_1 immediately before fork of M. Abdominal tergites obscure brownish yellow, with indications of a darker median stripe; sternites obscure yellow, the lateral margins darkened. Male hypopygium (Plate 2, fig. 11) with basistyles relatively slender, the mesal face grooved, at the bottom of this groove a small, oval, setiferous lobe. Dististyles unusually short, the glabrous one feebly expanded apically into a blade, apex weakly notched; setiferous style curved, clavate, with abundant short but conspicuous setæ. Gonapophyses slender, sinuous, their tips acute. Proctigers broad, almost straight across their caudal margins, their surface covered with abundant microscopic setæ.

Habitat.—Japan (Hokkaido).

Holotype, male, Sapporo, August 17, 1922 (*T. Esaki*).

Genus **PEDICIA** Latreille

Pedicia LATREILLE, Hist. Nat. Crust. et Ins. 4 (1809) 255.
Daimiotipula MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 463.

Pedicia daimio (Matsumura).

Daimiotipula daimio MATSUMURA, Thous. Ins. Japan, Ann. 2 (1916) 463.

Matsumura's type, a female, was from Sapporo, Hokkaido. A pair in the present collection is from Abashiri. The unknown male may be described as follows:

Allotype, male, length, 24 millimeters; wing, 23.

Antennal scape black, contrasting with the pale brown flagellum. Vertical tubercle high, conical. Head dark gray. Median prescutal stripe entire or very indistinctly bisected by a capillary pale vitta. Femora yellow, tips conspicuously blackened, more narrowly and abruptly on the posterior femora. Wings with the pattern dark brown; the brown band along cord connects with a narrow border uniting the spot at origin of Rs with the stigmal region, but isolates a large hyaline spot before stigma, immediately beneath tip of R_1; base of cell Cu very narrowly darkened. Venation: Rs square at origin, opposite Sc_2; petiole of cell M_1 only a little longer than m; cell 2d A broad. Abdomen with the basal tergite brightened, except medially; intermediate tergites brown, base narrowly pale; terminal segments dark brown, gray pruinose.

Allotype, male, Abashiri, Hokkaido, August 30, 1922 (*T. Esaki*).

Genus **RHAPHIDOLABINA** Alexander

Rhaphidolabina ALEXANDER, Proc. Acad. Nat. Sci. Phila. (1916) 540.

Rhaphidolabina gibbera Alexander.

Raphidolabina gibbera ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 121.

Toyohara, Saghalien, July 20, 1922 (*T. Esaki*); Maoka, Saghalien, July 28, 1922 (*T. Esaki*); Manui, Saghalien, August 3, 1922 (*T. Esaki*).

The species was described from rather imperfect material taken in central Honshiu. The following additional details of coloration should be given: The fore and middle legs are very different in color from the posterior legs, the femora being abruptly and entirely brownish black, the tibiæ and tarsi conspicuously light yellow, only the terminal segments of the latter being a little darkened.

The following notes by the collector are of interest. "These flies swarm like gnats and the black fore and middle femora look very strange in flight."—*Teiso Esaki.*

Genus **POLYANGAEUS** Doane

Polyangaeus DOANE, Journ. N. Y. Ent. Soc. 8 (1900) 196.

Polyangaeus gloriosus sp. nov.

General coloration yellowish ocherous; antennal flagellum yellow; legs yellow, femora and tibiæ broadly and conspicuously blackened terminally; wings subhyaline, with a brown, cross-banded pattern, the costal cell clear, sparsely variegated with darker; supernumerary cross veins in cells R_3, R_4, M_1, and M.

Male, length, 11 to 12 millimeters; wing, 9.6 to 10.

Rostrum and palpi brownish black. Antennæ very small, the first scapal segment black, the second dark brown; flagellum conspicuously light yellow, segments subglobular. Head dark brown, the occipital region a little paler. Pronotum broadly dark brown medially, the lateral portions ocherous. Mesonotal prescutum yellowish ocherous, with three broad reddish brown stripes that are practically confluent; scutal lobes reddish brown on their cephalic halves; scutellum and postnotum yellow. Pleura yellow, mesopleura indistinctly suffused with darker. Halteres pale, knobs weakly infuscated. Legs with coxæ yellow, the middle and posterior coxæ infuscated on their outer faces; trochanters yellow, their caudal margins slightly infuscated; femora and tibiæ yellow, tips broadly and very conspicuously brownish black, these areas approximately equal on all segments; basitarsi yellow, passing into brown at tip; remainder of tarsi dark brown. Wings subhyaline, with a handsome bright brown cross-banded pattern that is generally similar to that found in certain species of *Epiphragma,* distributed as follows: At base of wing; at origin of Rs, including both basal cells; along cord, completely traversing wing; at outer deflection of R_2; a broad subterminal band having m and the supernumerary cross veins in cells R_3, R_4 and M_1 as centers, continued to wing margin along veins; all of these brown areas are bordered with still darker brown; a series of from four to eight brown spots in cell Cu; area immediately behind vein Cu darkened; still darker brown areas at h; in cell C above Sc_2; in outer end of cell C; at end of cell Cu and vein 1st A; a large blotch at end of vein 2d A, and a smaller area in base of cell 1st A; veins yellow, darker in the infuscated areas. Venation: Sc_2 ending just before origin of Rs; outer deflection of R_2 from one to two times its length from tip of R_1; Rs angulated and spurred at origin; R_2 spurred immediately beyond base; cell R_3 petiolate, the petiole about equal to r-m; cell 1st M_2 closed; petiole of cell M_1 a little longer than m; basal deflection of Cu_1 about one-third its length beyond fork of M; supernumerary cross veins distributed as follows: in cell R_3 near the distal end, in cell R_4 at two-thirds the length; in cell M_1 at from one-third to one-half the length, in cell M opposite Sc_2. In the type, cell M_1 is sessile and unusually long, the supernumerary cross vein being at two-thirds the length. In a paratype, true r is present in both wings, just beyond spur on R_2. Basal abdominal tergites brown, paler laterally; basal sternites yellow, the caudal margins narrowly ringed with dark brown; terminal segments uniformly dark brown.

Habitat.—Japan (Saghalien).

Holotype, male, Shimizu, July 27, 1922 (*T. Esaki*).

Paratopotypes, 3 males.

Polyangaeus gloriosus is the largest and most beautiful species of the genus yet discovered.

Genus DICRANOTA Zetterstedt

Dicranota ZETTERSTEDT, Ins. Lapponica, Dipt. (1838) 851.

Dicranota yezoensis sp. nov.

Male, length, 6.3 millimeters; wing, 7.

Generally similar to *D. nipponica* Alexander, differing as follows: Antennæ of male elongate, if bent backward extending to mid-distance between base of wing and haltere; flagellar segments elongate, shiny black, with a white pubescence. General coloration of prescutum darker gray, stripes less contrasted. Wings with ground color somewhat darker, stigma distinct, dark brown; a distinct brown cloud extending from fork of Rs to end of r-m. Venation: Rs angulated and slightly spurred at origin; m present but faint, closing cell 1st M_2; petiole of cell M_1 about one-half longer than cell. Macrotrichiæ of wing veins longer and more conspicuous.

Habitat.—Japan (Hokkaido).

Holotype, male, Lake of Akan, September 4, 1922 (*T. Esaki*).

Genus RHAPHIDOLABIS Osten Sacken

Rhaphidolabis OSTEN SACKEN, Mon. Dipt. N. Am. 4 (1869) 284.

Rhaphidolabis flavibasis Alexander.

Rhaphidolabis flavibasis ALEXANDER, Ann. Ent. Soc. Am. 12 (1919) 343.

One female from Toyohara, Saghalien, July 17, 1922 (*T. Esaki*). The species was described from Honshiu, but has not yet been found in Hokkaido.

Rhaphidolabis subconsors sp. nov.

Male, length, about 4.5 millimeters; wing, 6.1.

Generally similar to *R. consors* Alexander, differing as follows: Pronotum, mesonotal prescutum, scutum, postnotum, and thoracic pleura dark gray, scutellum and posterior portions of the scutal lobes reddish; prescutum with a distinct black median stripe and less distinct lateral stripes. Wings with petiole of cell M_3 only as long as the basal deflection of Cu_1. Male hypopygium with the mesal apical angle of basistyle produced into a short, broad, blunt lobe, the truncate apex of which is densely set with strong setæ. Outer dististyle triangular, fleshy, surface with abundant, hairlike setæ; inner dististyle smooth, large, and flattened. Lateral gonapophyses appearing as long, strongly curved hooks, the long acute tips of which are produced mesad and cephalad, almost contiguous on midline of body.

Habitat.—Japan (Hokkaido).

Holotype, male, Lake Shikotsu, September 24, 1922 (*T. Esaki*).

Tribe HEXATOMINI

Genus **ULA** Haliday

Ula HALIDAY, Ent. Mag. 1 (1833) 224.

The genus *Ula* includes six described species, all being Holarctic with the exception of a single Javanese species. The relationships of this genus are in doubt, the details of structure of the adult pointing to the tribe Pediciini, those of the larvæ and pupæ to the Hexatomini. The present collection contained two additional undescribed species.

Ula perelegans sp. nov.

General coloration gray; antennæ long; wings with a heavy brown pattern; cell 1st M_2 relatively large.

Female, length, about 5.5 millimeters; wing, 8.

Rostrum dark gray, palpi black. Antennæ long for this sex, if bent backward extending to base of halteres, black throughout. Head light gray. Pronotum light gray. Mesonotum black, gray pruinose, on prescutum leaving a median black stripe exposed. Pleura pale brown, sparsely pruinose, the dorsopleural membrane obscure yellow. Halteres yellow, knobs feebly infuscated. Legs with coxæ and trochanters yellow; femora brown, bases broadly yellow, narrowest on forelegs where about the basal quarter is included; on the posterior legs the brown includes only the relatively narrow apices; tibiæ and tarsi pale brown, tarsi darker. Wings pale yellow with a heavy brown pattern, distributed as follows: A small spot at Sc_2; large spots at origin of Rs, tip of Sc_1 and at r, the latter two delimiting a conspicuous yellowish stigmal area, the former confluent with a conspicuous seam along cord, continued to wing margin along vein Cu_2; outer end of cell 1st M_2 seamed with brown; veins brown. Venation: Sc_2 near midlength of distance between arculus and origin of Rs; r its own length from tip of R_1; basal deflection of R_{4+5} very short; r-m correspondingly lengthened, feebly arcuated; cell 1st M_2 rather large, as long as vein Cu_1 beyond it; basal deflection of Cu_1 about one-fourth its length beyond fork of M. Abdominal tergites infuscated, especially the basal and subterminal segments; sternites light yellow; ovipositor with valves strongly upcurved.

Habitat.—Japan (Hokkaido).

Holotype, female, Abashiri, August 30, 1922 (*T. Esaki*).

Ula cincta sp. nov.

General coloration shiny yellowish brown; antennæ long; wing pattern faintly indicated; cell 1st M_2 small; abdominal segments dark brown, the caudal margins narrowly ringed with obscure yellow.

Female, length, 5.6 to 5.8 millimeters; wing, 6.3 to 6.8.

Rostrum and palpi black. Antennæ elongate, if bent backward extending at least to base of halteres; scapal segments pale, the flagellar segments dark. Head dull gray. Mesonotal prescutum shiny yellowish brown, scutellum and postnotum darker brown. Pleura light brown. Halteres pale, knobs infuscated. Legs with coxæ and trochanters pale brownish yellow, fore coxæ a little infuscated basally; legs pale brown, tibiæ and tarsi darker; extreme tips of femora infuscated. Wings faintly tinged with brown, with faint indications of darker markings at origin of Rs, along cord, and at either end of the faintly indicated stigma; veins uniformly pale brown. Venation: Sc_2 about three-fifths the distance between arculus and origin of Rs; cell 1st M_2 relatively small, shorter than the distal section of Cu_1. Abdomen dark brown, the caudal margins of segments narrowly ringed with obscure yellow. Ovipositor with the tergal valves strongly upcurved to the acute tips.

Habitat.—Japan (Hokkaido).

Holotype, female, Akan, September 3, 1922 (*T. Esaki*).

Paratype, 1 female, Teppetsu, September 9, 1922 (*T. Esaki*).

Genus **EPIPHRAGMA** Osten Sacken

Epiphragma OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 238.

Epiphragma subinsignis Alexander.

Epiphragma subinsignis ALEXANDER, Trans. Am. Ent. Soc. 46 (1920) 11, 12.

One female from Maruyama, near Sapporo, Hokkaido, August 17, 1922 (*T. Esaki*). The types are from Saitama and Mount Takao, near Tokyo, Honshiu.

Genus **LIMNOPHILA** Macquart

Limnophila MACQUART, Hist. Nat. Ins., Dipt. (1834) 95.

The type of the genus *Limnophila* is *L. pictipennis* Meigen, this having been designated by Westwood in 1840. One species of the typical subgenus was included in the present material. The other species fall in various subgeneric groups, some of which may not be strictly congeneric when better known.

Limnophila (Limnophila) japonica Alexander.

Limnophila japonica ALEXANDER, Can. Ent. 45 (1913) 316, 317.

Saghalien: Toyohara, July 18, 1922; Manui, August 3, 1922. Hokkaido: Kamiotoineppu, August 24, 1922.

The Saghalien specimens have the basal flagellar segment black with only the extreme base pale, but seem to be referable to this species.

Limnophila inconcussa Alexander.

Limnophila inconcussa ALEXANDER, Can. Ent. 45 (1913) 313, 314.

This is a common and widely distributed crane fly, ranging from Hokkaido to Taiwan. The present collection includes the following material, collected by Doctor Esaki:

Hokkaido: Kamiotoineppu, August 23, 1922; Shikaripetsu, August 26, 1922; Abashiri, August 31, 1922; Akan, September 6, 1922.

Limnophila unicoides sp. nov.

Allied to *L. unica* Osten Sacken; general coloration dark chocolate brown; antennæ of male elongate; wings with a faint brown tinge; stigma large, dark brown; a brown cloud at r-m; cell 1st M_2 large, cell M_1 deep.

Male, length, about 9 millimeters; wing, 8. Female, length, 8.5 to 10 millimeters; wing, 9 to 9.5.

Rostrum and palpi brownish black, the former dusted with gray. Antennæ elongate, the basal segment dark brown;

second scapal segment obscure yellow; flagellum dark brown; segments elongate. Head brown, pruinose. Mesonotum dark chocolate brown, with a very sparse yellowish pollen, scutellum and postnotum more pruinose. Pleura dark brown, gray pruinose. Halteres obscure yellow, knobs infuscated. Legs with coxæ obscure yellow, their bases infuscated; trochanters yellow; remainder of legs dark brown, the femoral bases narrowly obscure brownish yellow, narrowest on forelegs, broadest on hind legs. Wings with a faint brownish tinge; stigma large, dark brown; a conspicuous brown cloud at r-m and the basal deflection of R_{4+5}; an indistinct cloud at origin of Rs; veins dark brown. Venation: Sc long, Sc_1 ending slightly beyond fork of Rs, the usually longer Sc_2 at its extreme tip; Rs long; R_{2+3} subequal to the distal section of R_2; r a little shorter than tip of R_1; inner ends of cells R_3, R_5 and 1st M_2 in alignment; cell 1st M_2 large, widened distally; petiole of cell M_1 about one-half longer than m, cell M_1 being very deep; basal deflection of Cu_1 before or near midlength of cell 1st M_2. A paratype has an adventitious cross vein in cell R_3 of one wing. Abdominal tergites dark brown, the basal sternites obscure brownish yellow; hypopygium black. In female, sternites are uniformly darkened. Male hypopygium with the mesal face of basistyle produced caudad as a stout, blunt lobe; dististyles two, the outer style a flattened, bladelike structure that terminates in a slender, curved, black spine; inner style slender, foot-shaped, at apex bent cephalad at a right angle into a long, slender beak; on the caudal margin near base, a slender, black, slightly curved spine. Gonapophyses appearing as two sets of black curved spines, directed mesad, the lateral pair longer and more strongly curved.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Shimizu, Saghalien, July 27, 1922 (*T. Esaki*).

Allotype, female, Kamiotoineppu, Hokkaido, August 24, 1922 (*T. Esaki*).

Paratypes, 1 female, Teppetsu, Hokkaido, September 9, 1922 (*T. Esaki*); 1 female, Akan, Hokkaido, September 4, 1922 (*T. Esaki*).

Limnophila subpoetica sp. nov.

Allied to *L. poetica* Osten Sacken; general coloration reddish brown; femora black, broadly yellowish basally; wings tinged with grayish yellow, stigma dark brown; Rs long, cell 2d A broad.

Male, length, 10 millimeters; wing, 9.5.

Rostrum and palpi brownish black. Antennæ moderately elongate, if bent backward extending to beyond base of abdomen; scape dark brown; basal flagellar segment obscure yellow; remainder of flagellum dark brown. Head gray. Mesonotal prescutum reddish brown, sparsely pollinose, scutellum and postnotum slightly more pruinose. Pleura concolorous. Halteres pale, knobs a little darker. Legs with coxæ and trochanters obscure yellow; femora black, bases broadly obscure yellow, narrowest on forelegs where less than the basal third is included, broadest on hind legs where more than the basal half is included; tibiæ brown, passing into dark brownish black at tips and on tarsi. Wings with a grayish yellow tinge, brighter yellow at base and in cells C and Sc; stigma oval, dark brown; narrow and inconspicuous brown seams at origin of Rs, along cord and outer end of cell 1st M_2, and at wing apex. Venation: Rs long, square and spurred at origin, in alignment with R_{2+3}; r at tip of R_1; inner ends of cells R_3, R_5 and 1st M_2 in approximate alignment; cell M_1 present, a little longer than its petiole; cell 1st M_2 rectangular, the basal deflection of Cu_1 about one-third its length beyond fork of M; cell 2d A much broader than in *L. kuwayamai* Alexander. Abdomen reddish brown, variegated with black; terminal segments uniformly blackened, including hypopygium. Male hypopygium with the ninth tergite produced into a long, fingerlike lobe on either side of median line; dististyles two, the outer long and slender with the narrow apex strongly curved, the inner dististyle dilated basally, apex paler. Gonapophyses small, curved, base of each produced laterad into a small, bidentate lobe.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 25, 1922 (*T. Esaki*).

Limnophila nemoralis (Meigen) var.

Limnobia nemoralis MEIGEN, Syst. Beschr. 1 (1818) 126.

One female from Toyohara, Saghalien, July 20, 1922 (*Teiso Esaki*) cannot be distinguished from European material. It is possible that the male sex will show subspecific differences.

Limnophila (Phylidorea) subadusta sp. nov.

General coloration dull reddish brown; head gray; legs black, the femoral bases broadly yellow; wings tinged with yellow, sparsely spotted and seamed with brown; abdomen dark brown, segments narrowly ringed caudally with pale.

Female, length, 9.5 millimeters; wing, 8.

Rostrum and palpi black. Antennæ with the basal segment dark brown; second scapal and basal one or two flagellar segments yellow, the terminal segments dark brown. Head gray. Pronotum dark brown. Mesonotal prescutum dull reddish brown, prescutum more infuscated medially, surface feebly pollinose. Pleura reddish brown, mesepisternum infuscated, surface slightly pollinose. Halteres yellow, knobs very slightly infuscated. Legs with coxæ and trochanters yellow; femora black, their bases bright yellow, on forelegs including about the basal third, more extensive on the other legs; tibiæ brownish black; tarsi black. Wings tinged with yellow, base and cells C and Sc more yellowish; stigma conspicuous, oval, dark brown; wing tip suffused with brown; conspicuous but narrow brown spots and seams at origin of Rs; along cord and outer end of cell 1st M_2; fork of M_{1+2}; veins brownish black, paler in the flavous areas. Venation: Sc_1 ending immediately before fork of Rs, Sc_2 at its tip; Rs long for a member of the *ferruginea* group, one-half longer than cell 1st M_2, square and spurred at origin; R_{2+3} about equal to basal deflection of R_{4+5}; r at tip of R_1; petiole of cell M_1 about as long as cell; basal deflection of Cu_1 near midlength of cell. Abdominal tergites dark brown, apices of segments indistinctly paler; basal sternites obscure yellow, the remaining sternites concolorous with tergites. Ovipositor with the valves dark horn color.

Habitat.—Japan (Saghalien).

Holotype, female, Manui, August 3, 1922 (*T. Esaki*).

Limnophila (Phylidorea) sapporensis Alexander.

Limnophila sapporensis ALEXANDER, Insec. Inscit. Menst. 9 (1921) 181, 182.

The following records are included in the present collection: Saghalien: Manui, August 3, 1922; Odasam, August 5, 1922; Odomari, August 8, 1922 (*T. Esaki*).

The type locality is Hokkaido.

Genus **PILARIA** Sintenis

Pilaria SINTENIS, Sitzber. Nat. Ges. Dorpat 8 (1888) 398.

Species of the genus *Pilaria* are found throughout the Holarctic Region and in Madagascar.

Pilaria dorsalis sp. nov.

Size large (wing of female, over 10 millimeters); head dull black; antennæ elongate; general coloration of thorax obscure reddish yellow, prescutum and scutal lobes shiny black; femora and tibiæ obscure brownish yellow.

Female, length, about 9 millimeters; wing, 10.5 to 12.

Rostrum pale brown, palpi black. Antennæ elongate, scape black, the basal flagellar segment pale at base; remainder of organ black. Head dull black, light gray pruinose. Pronotum very narrow, obscure yellow, darker anteromedially. Mesonotum shiny black, the region of the pseudosutural foveæ obscure yellow; lateral margins very narrowly of the same color; scutum obscure yellow medially, lobes shiny black, narrowly connected across the median line; scutellum and postnotum obscure reddish brown, the former sometimes blackened medially. Pleura obscure reddish yellow. Halteres yellow, knobs weakly infuscated. Legs with coxæ and trochanters yellow; femora and tibiæ obscure brownish yellow, tips narrowly and indistinctly infuscated; tarsi dark brown. Wings with a faint brownish tinge, base and costal region more yellowish; stigma very small and faint, brown, veins dark brown. Venation: Sc ending just before fork of Rs, Sc_2 at tip of Sc_1; Rs long, straight, base arcuated; r at fork of R_{2+3}; cell M_1 about as long as its petiole; basal deflection of Cu_1 near two-thirds the length of cell 1st M_2. Abdomen dark brown, sternites a little paler. Ovipositor with the long, acicular valves horn-colored, basal plate black.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, female, Konuma, Saghalien, July 17, 1922 (*T. Esaki*).

Paratype, female, Sapporo, Hokkaido, June 19, 1921 (*M. Hori*), No. 55.

Genus **ERIOCERA** Macquart

Eriocera MACQUART, Dipt. Exot. 1 (1838) 74.

The very large genus *Eriocera* is represented in the collection by two species belonging to the *spinosa* group of the genus. Their nearest allies are found in the Nearctic Region.

Eriocera jozana sp. nov.

Male, length, 14 millimeters; wing, 22; antenna, 61.

Generally similar to *E. stricklandi* Edwards, differing as follows:

Antennæ with the enlarged basal segment ocherous on the ventral half; flagellar segments 1 to 4 gradually elongated, the entire organ more than four times the length of body. Vertical tubercle very large and conspicuous. Thoracic vestiture long and conspicuous, erect; lateral margins of prescutum not conspicuously brightened, pruinose; median prescutal stripe indistinctly bifid posteriorly. Legs with the black tips of fore femora narrower; posterior femora black with only the extreme base brightened; tibiæ not darkened basally. Wings with stigma clearly defined, oval, brown; cell 1st M_2 long and narrow, rectangular; cell M_1 about equal in length to its petiole. Abdominal segments dark brown, ocherous laterally, the caudal margins of the posterior sternites broadly pale.

Habitat.—Japan (Hokkaido).

Holotype, male, Jozankei, August 19, 1922 (*T. Esaki*).

Eriocera sachalinensis sp. nov.

Belongs to the *spinosa* group; antennæ of male shorter than body; mesonotal prescutum gray with four conspicuous dark brown stripes; cell M_1 present.

Male, length, 16 to 18 millimeters; wing, 20 to 21; antenna, 11.5 to 12.

Rostrum and palpi brownish black. Antennæ of moderate length, shorter than body; basal segment dark, reddish basally beneath; flagellum black, segments 1 to 4 gradually more elongated. Head brown, gray pruinose; a conspicuous reddish brown area on either side of the vertical tubercle. Mesonotal prescutum gray, with four conspicuous dark brown stripes; scutum gray, each lobe with a conspicuous, dark brown, central blotch; scutellum brownish gray, more yellowish laterally, clothed with abundant long, pale setæ; postnotum brownish plumbeous. Pleura dark colored, light gray pruinose. Halteres light brownish ocherous, knobs dark brown. Legs with coxæ light gray; trochanters brown; femora dark brown, bases broadly and conspicuously obscure fulvous, on the posterior legs occupying a little less than the basal half; remainder of legs brownish black. Wings with a strong brownish yellow tinge, base and cells C and Sc more saturated; stigma small, oval, dark brown; veins dark brown. Venation: r near midlength of vein R_2; cell M_1 present, longer than its petiole. Abdomen dark brown, pruinose; lateral margins of tergites narrowly ocherous.

Habitat.—Japan (Saghalien).

Holotype, male, Takinosawa, July 26, 1922 (*T. Esaki*).

Paratypes, 1 male, Shimizu, July 27, 1922 (*T. Esaki*), 1 male, Maoka, July 28, 1922 (*T. Esaki*).

Genus **ELEPHANTOMYIA** Osten Sacken

Elephantomyia OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 220.

Elephantomyia (Elephantomyia) hokkaidensis sp. nov.

General coloration shiny brownish yellow; legs with femora dark brown, tibiæ and tarsi brownish yellow; wings tinged with yellow, apex infuscated; abdomen yellow, tergites with a longitudinal median stripe; sternites ringed caudally with black.

Male, length (excluding rostrum), 6 to 10 millimeters; wing, 8.5 to 12. Female, length (excluding rostrum), 9 to 11 millimeters; wing, 9 to 11.

Rostrum longer than body, brown, including palpi. Antennæ with scape dark brown; basal flagellar segments brownish yellow, becoming more infuscated toward tip of the organ. Head yellowish pruinose anteriorly, more yellow to brownish yellow behind. Pronotum infuscated medially. Mesonotum shiny brownish yellow to brown, without markings. Pleura concolorous. Halteres pale, knobs weakly infuscated. Legs with coxæ and trochanters yellowish testaceous; femora brown, soon passing into dark brown; tibiæ and basal segments of tarsi brownish yellow, the terminal tarsal segments infuscated. Wings tinged with yellow; apex distinctly infuscated; stigma elongate-oval, brown; cord and outer end of cell 1st M_2 narrowly and indistinctly clouded with darker; veins dark brown. Venation: Sc_1 ending nearly opposite fork of Rs, Sc_2 at tip of Sc_1; cell 1st M_2 large, rectangular; basal deflection of Cu_1 close to midlength of cell. Abdomen yellow, tergites with a median black longitudinal stripe, in some female individuals broken into triangles; sternites conspicuously ringed caudally with black; a black subterminal ring in male; hypopygium obscure yellow. Male hypopygium with the mesal face of basistyles densely setiferous; outer dististyle slender, suddenly curved at apex, before tip on the outer side with a small tooth; inner style a little longer, enlarged on basal half, setiferous. Gonapophyses slender, produced into a filiform point. Penifilum coiled in a transverse spring, suggesting a watch spring.

Habitat.—Japan (Hokkaido).

Holotype, male, Abashiri, August 30, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotypes, 2 males, 3 females; paratypes, 7 males and females, Kamiotoineppu, August 23, 25, 1922 (*T. Esaki*); 5 males and females, Shikaripetsu, August 26, 1922 (*T. Esaki*); 2 males and females, Kamiokoppe, August 27, 1922 (*T. Esaki*); 1 female, Ponkikin, September 2, 1922 (*T. Esaki*); 7 males and females, Akan, September 3, 4, 1922 (*T. Esaki*); 4 males and females, Panketo, September 6, 1922 (*T. Esaki*); 6 males and females, Shikotsu, September 24, 1922 (*T. Esaki*).

Most of the above specimens were taken while feeding on nectar of various Compositæ plants; a few came to light.

Genus **MOLOPHILUS** Curtis

Molophilus CURTIS, Brit. Ent. (1833) 444.

In addition to the new species described herewith, the collection included female specimens of at least one additional species of *Molophilus* that cannot be determined more accurately.

Molophilus albibasis sp. nov.

General coloration black; antennæ short; halteres white; wings faintly tinged with brown, their bases white; male hypopygium with the mesal apical angle of basistyle terminating in a powerful black spine.

Male, length, about 4 millimeters; wing, 4.5.

Rostrum and palpi black. Antennæ short, dark brown. Head black. Mesonotum black, pleura dark brownish black. Halteres white. Legs dark brownish black. Wings with a faint brownish tinge, base conspicuously whitish to a short distance beyond arculus; veins conspicuously dark brown. Venation: Vein 2d A comparatively short, ending before level of fork of M. Abdomen dark brown, including hypopygium. Male hypopygium very distinct in structure; each basistyle stout, the lateral apical angle produced caudad into a long, stout, cylindrical, setiferous lobe that is as long as any of the elements of hypopygium; mesal apical angle of basistyle produced into a shorter, glabrous lobe that bears near its tip a powerful, curved, black spine. Dististyles two, lying in the notch between the lobes of basistyle; longest style slender, bifid near its tip, the arms thus formed relatively long and slender; inner style a short, blackened blade, slightly curved beyond midlength, the margin with microscopic spinulæ.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 16, 1922 (*T. Esaki*).

Genus **ERIOPTERA** Meigen

Erioptera MEIGEN, Illiger's Mag. 2 (1803) 262.

Erioptera (Erioptera) elegantula Alexander.

Erioptera elegantula ALEXANDER, Can. Ent. 45 (1913) 290, 291.

Doctor Esaki's material included the following records: Hokkaido: Sapporo, August 17, 1922; Kamuikotan, August 22, 1922; Abashiri, August 31, 1922.

Erioptera (Erioptera) xanthoptera sp. nov.

General coloration brown; antennæ pale brown; halteres and legs obscure yellow; wings with a strong yellowish tinge.

Female, length, 6 millimeters; wing, 7.

Rostrum and palpi pale brown. Antennæ pale brown throughout. Head light brown, sparsely pollinose, occiput slightly more fulvous. Mesonotum brown with a light yellow pollinosity. Pleura light brown. Halteres short, obscure yellow, knobs a very little darker. Legs with coxæ and trochanters concolorous with pleura; remainder of legs obscure yellow, the terminal tarsal segments infuscated. Wings with a strong yellow tinge, veins darker yellow. Venation: Vein 2d A strongly sinuous. Abdominal tergites brown, the caudal and lateral margins of segments a little brighter; sternites brownish black. Ovipositor with the tergal valves strongly upcurved.

Habitat.—Japan (Saghalien).

Holotype, female, Konuma, July 17, 1922 (*T. Esaki*).

Erioptera (Erioptera) flavohumeralis sp. nov.

Mesonotal prescutum yellow, with three conspicuous brown stripes; halteres obscure yellow; femora dark brown, bases broadly pale; wings tinged with brownish yellow.

Male, length, about 5.5 millimeters; wing, 5.7. Female, length, about 6 millimeters; wing, 6.2.

Rostrum and palpi black. Antennæ with the basal segment brownish black, the second segment pale brown; flagellum dark brown. Head pale. Pronotum obscure yellow, darker medially. Mesonotal prescutum yellow, with three conspicuous brown stripes, the humeral region broadly yellow; scutum yellow, lobes with brown centers; scutellum and postnotum obscure yellow, the latter darker posteriorly. Pleura ocherous, very sparsely pruinose; sternopleura darker. Halteres obscure yellow. Legs with coxæ yellow, fore coxæ darker basally; trochanters yellow; femora dark brown, bases broadly paler; tibiæ and basal segments of tarsi obscure yellow, the terminal segments darker.

Wings tinged with brownish yellow, cells beyond cord darker, especially near wing tip; veins brownish yellow. Venation: Vein 2d A strongly sinuous. Abdomen dark brown. Male hypopygium (Plate 2, fig. 21) with the outer dististyle slender, at apex dilated into a semicircular blade, before apex of which on the outer margin with a conspicuous erect spine. Gonapophyses widely separated at base, directed mesad, before tips slightly dilated and produced into acute blackened points.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 19, 1922 (*T. Esaki*).

Allotopotype, female.

Erioptera (Erioptera) horii sp. nov.

General coloration light yellow; head silvery whitish; halteres with dark brown knobs.

Male, length, 4.5 to 4.7 millimeters; wing, 5.5. Female, length, 5.5 millimeters; wing, 5.6 to 5.8.

Rostrum yellow, palpi dark brown. Antennæ yellow, the terminal segments darkened, the basal segment sparsely pruinose. Head silvery white; eyes large. Pronotum white. Mesonotal prescutum pale ocherous yellow, unmarked, the lateral margins paler. Pleura whitish yellow. Halteres yellow, knobs conspicuously dark brown. Legs with coxæ and trochanters yellowish testaceous; remainder of legs yellow, the terminal tarsal segments darkened. Wings clear yellow, veins a little darker, with brownish yellow macrotrichiæ. Venation: Vein 2d A long and very strongly sinuous. Abdomen yellow. Male hypopygium (Plate 2, fig. 22) with the caudal mesal angle of each basistyle produced into a conical lobe; outer dististyle a slender black rod that tapers gradually to the acute apex; inner dististyle shorter, gently curved, beyond midlength on the outer margin with a long, erect spine; margin at apex produced into a flattened bi- or tridentate blackened blade. Gonapophyses small, relatively inconspicuous, the mesal edge blackened. Ovipositor with long, gently curved, slender valves, their margins smooth.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Jozankei, August 19, 1922 (*T. Esaki*).

Allotopotype, female.

Paratype 1 male, Toyohara, Saghalien, July 13, 1922 (*T. Esaki*); 1 female, Toyohara, July 21, 1922 (*T. Esaki*); 1 female, Sapporo, Hokkaido, August 2, 1921 (*M. Hori*); 1 male, Sapporo, August 18, 1922 (*T. Esaki*); 1 female, Kamiotoineppu, August

24, 1922 (*T. Esaki*); 1 female, Abashiri, August 31, 1922 (*T. Esaki*).

This interesting species is named in honor of the collector of one of the paratype specimens, Mr. M. Hori.

Erioptera (Erioptera) orbitalis sp. nov.

General coloration reddish brown, the postnotum and pleura blue-gray pruinose; antennæ dark brown, the first flagellar segment obscure yellow; head brownish black with narrow silvery orbital lines; wings tinged with fulvous yellow.

Female, length, 5.3 millimeters; wing, 5.5.

Rostrum reddish brown, palpi dark brown. Antennæ with the scapal segments dark brown; first flagellar segment obscure yellow, the remaining segments of flagellum passing into brown. Head brownish black with a narrow silvery line adjoining the inner margin of eye, confluent on anterior part of vertex. Mesonotal prescutum reddish brown, postnotum pruinose. Pleura pale, conspicuously pale blue-gray pruinose. Halteres pale, knobs dark brown. Legs with coxæ and trochanters yellow, fore coxæ blue-gray pruinose; trochanters yellow; femora and tibiæ yellow; tarsi brownish yellow, the terminal tarsal segments passing into dark brown. Wings with a strong fulvous yellow tinge, veins darker. Venation: Vein 2d A strongly sinuous. Abdomen yellowish brown, sternites a little brighter. Ovipositor with the tergal valves long and very gently curved.

Habitat.—Japan (Hokkaido).

Holotype, female, Sapporo, August 17, 1922 (*T. Esaki*).

Erioptera (Acyphona) asymmetrica Alexander.

Erioptera asymmetrica ALEXANDER, Can. Ent. 45 (1913) 289, 290.

The following records are available in the present material: Hokkaido: Sapporo, August 17, 1922; Kamuikotan, August 22, 1922; Abashiri, August 31, 1922 (*T. Esaki*).

Erioptera (Acyphona) sachalina sp. nov.

Allied to *E. areolata* Siebke (northern Europe); general coloration pale brownish ocherous; knobs of halteres yellow; legs obscure yellow, tips of femora, tibiæ, and tarsi infuscated; male hypopygium with the intermediate chitinized lobe of dististyle simple.

Male, length, 2.6 millimeters; wing, 4 to 4.4. Female, length, 3.3 millimeters; wing, 5.5.

Rostrum and palpi dark brown. Antennæ with the basal segments light yellow, the flagellar segments beyond the basal one or two passing into light brown. Head light brown, sparsely pruinose. Mesonotum and pleura uniformly pale brownish ocherous. Halteres pale, knobs yellow. Legs with coxæ and trochanters ocherous; remainder of legs obscure yellow, tips of femora and tibiæ and the terminal tarsal segments faintly darkened. Wings with a grayish yellow tinge, base and cells C and Sc clearer yellow; veins pale brown. Venation: Cell 1st M_2 closed, very small as in the *areolata* group; basal deflection of Cu_1 slightly before fork of M; vein 2d A short and straight. Abdomen pale brownish ocherous. Male hypopygium with the ninth tergite (Plate 2, fig. 15) chitinized, the caudal margin with a broad, V-shaped notch, the lateral angles rounded; from beneath tergite on either side arises a broad plate (Plate 2, fig. 17) that is asymmetrically bifid, the mesal arm a short, blackened spine, directed mesad and nearly contiguous with its mate of the opposite side, separated therefrom by a small oval notch; the lateral arm is directed caudad into a long, blackened spine. Basistyle produced caudomesad into a long fleshy point; a single, very complex dististyle (Plate 2, fig. 19) near midlength of its mesal face, this consisting of a basal fleshy setiferous arm, and a tripartite flattened blade with the margins of all three parts chitinized, including a basal oval lobe, an intermediate simple spine, and a longer, curved, chitinized blade that runs out into a spine.

Habitat.—Japan (Saghalien).

Holotype, male, Shimizu, July 27, 1922 (*T. Esaki*).

Allotype, female, Toyohara, July 7, 1922 (*T. Esaki*).

Paratypes, 6 males and females, with the allotype, July 14 to 20, 1922 (*T. Esaki*).

Erioptera (Acyphona) yezoana sp. nov.

Male, length, about 3 millimeters; wing, 4.

Generally similar to *E.* (*A.*) *sachalina* sp. nov., differing as follows:

Antennæ longer, if bent backward extending at least to base of halteres. General coloration of head and thorax more pruinose, giving body a grayish ocherous cast. Wings with the basal section of R_2 perpendicular, subequal in length to r; cell 1st M_2 tending to be open by the atrophy of m. Male hypopygium with the lateral angles of tergite (Plate 2, fig. 16) rectangular or acute; the median V-shaped notch more sinuous in outline, its point deeper; the plate arising from beneath tergite (Plate 2, fig. 18) appears as two long slender spines, directed caudad, the mesal spine about one-half the length of the lateral spine and slenderer. Dististyle (Plate 2, fig. 20) generally similar to the condition in *E. sachalina* but the basal fleshy setiferous arm is very short and stout; intermediate chitinized arm profoundly bifid; apical blade longer and slenderer.

Habitat.—Japan (Hokkaido).

Holotype, male, Shitakara, September 10, 1922 (*T. Esaki*).

Erioptera (Hoplolabis) asiatica Alexander.

Erioptera asiatica ALEXANDER, Ann. Ent. Soc. Am. 11 (1918) 447, 448.

The species had been previously known only from Honshiu. The present collection includes the following additional records:

Saghalien: Toyohara, July 17, 18, 1922 (T. Esaki); Hokkaido: Kamuikotan, August 17, 1922 (*T. Esaki*).

Genus **ORMOSIA** Rondani

Ormosia RONDANI, Dipt. Ital., Prodr. 1 (1856) 180.
Rhypholophus KOLENATI, Wien. Ent. Monatschr. 4 (1860) 393.

The extensive genus *Ormosia* is represented in the Esaki collection by two or three species, all but one being represented by female specimens only. As has been indicated in other papers, it is impossible to determine the female sex of many of the larger and more complex groups of crane flies.

Ormosia subdeviata sp. nov.

Allied to *O. deviata* Dietz (eastern North America); general coloration brown, the prescutal stripes confluent; pleura dark; r close to fork of R_{2+3}.

Male, length, about 3.5 millimeters; wing, 4.3.

Rostrum and palpi brown. Antennæ short, brown. Head brown. Mesonotal prescutum brown, the usual stripes confluent, the humeral region surrounding the pseudosutural foveæ ocherous; scutal lobes brown; scutellum and postnotum paler brown. Pleura dark brown, sparsely pruinose, with an indistinct paler longitudinal stripe. Halteres brown, stem with golden yellow setæ. Legs with coxæ and trochanters ocherous; femora light brownish yellow, becoming a little darker toward tips; tibiæ and tarsi brown, the terminal tarsal segments dark brown. Wings subhyaline, stigma conspicuous but ill-defined, brown; veins dark brown. Venation: r immediately beyond base of R_2; veins R_2 and R_3 divergent; cell 1st M_2 open by the atrophy of the outer deflection of M_3; basal deflection of Cu_1 at fork M; anal veins strongly divergent. Abdomen dark brown, hypopygium somewhat paler. Male hypopygium of the same general structure as in the *deviata* group, the ninth tergite (the *apparent* sternite) being produced caudad into a very large, sheathlike structure that is profoundly bifid. Dististyles two, the outer one a little shorter than the inner, subglabrous. Gonapophyses acicular, as in the group.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 23, 1922 (*T. Esaki*).

Genus **CHEILOTRICHIA** Rossi

Cheilotrichia Rossi, Verz. Österreich. Dipt. (1848) 12.

It was a matter of great surprise to find in Esaki's Saghalien material a small series of the type species of this isolated monotypical genus. A critical comparison with numerous European specimens has failed to reveal any differences whatsoever.

Cheilotrichia imbuta (Meigen).

Erioptera imbuta Meigen, Syst. Beschr. 1 (1818) 114, pl. 4, fig. 8.

The following records for this handsome little fly are included in the present collection:

Saghalien: Konuma, July 22, 1922 (on a fungus); Shimizu, July 27, 1922; Manui, August 3, 1922 (*T. Esaki*).

The collector notes that the flies swarm in the evening.

Genus **HELOBIA** St. Fargeau

Helobia St. Fargeau, Encycl. Meth., Ins. 10 (1825) 585.
Symplecta Meigen, Syst. Beschr. 6 (1830) 282.

Helobia hybrida (Meigen).

Limnobia hybrida Meigen, Klass 1 (1804) 57.

A few specimens of this common and widespread species were included in the present material:

Saghalien: Toyohara, July 20, 21, 1922 (*T. Esaki*); Hokkaido: Sapporo, August 17, 1922; Jozankei, August 19, 1922; Abashiri, August 31, 1922 (*T. Esaki*).

Genus **GNOPHOMYIA** Osten Sacken

Gnophomyia OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 223.

The only species included in the present collection is an undescribed form that is most closely related to the Nearctic *Gnophomyia tristissima* Osten Sacken, the genotype.

Gnophomyia tristis sp. nov.

General coloration black; halteres with knobs dirty white; wings with a strong fuscous tinge; stigma elongate-oval, dark brown.

Female, length, about 8.5 millimeters; wing, 6.8.

Rostrum and palpi black. Antennæ moderately elongate, black. Head black, the anterior part of vertex faintly pruinose. Thorax entirely dull black. Halteres dark brown, knobs dirty white. Legs with coxæ and trochanters dull black; remainder of legs brownish black. Wings with a strong fuscous tinge; stigma elongate-oval, dark brown; veins brownish black. Venation: Sc_1 ending just before fork of R_{2+3}, Sc_2 far from tip of Sc_1, the latter alone nearly as long as R_{2+3}; r on R_2 about its own length beyond fork of R_{2+3}; cell 1st M_2 elongate, only slightly widened distally; basal deflection of Cu_1 about one-half its length beyond fork of M. Abdomen black. Ovipositor with the valves long, the basal plate constricted.

Habitat.—Japan (Saghalien).

Holotype, female, Toyohara, July 21, 1922 (*T. Esaki*).

Genus **GONOMYIA** Meigen

Gonomyia MEIGEN, Syst. Beschr. 1 (1818) 146.

Three of the four subgenera were included in the present material, these being *Gonomyia* Meigen, *Ptilostena* Bergroth, and *Lipophleps* Bergroth.

Gonomyia (Gonomyia) superba Alexander.

Gonomyia superba ALEXANDER, Can. Ent. 45 (1914) 285, 286, pl. 3, fig. 14.

Two specimens from Abashiri, Hokkaido, August 31, 1922 (*T. Esaki*), were in the present collection.

Gonomyia (Ptilostena) subpruinosa sp. nov.

General coloration ash gray, mesonotal prescutum ash gray with two intermediate pale brown stripes; pleura pale brown with an obscure yellow longitudinal stripe; wings with a yellowish tinge; stigma ill defined, brown; Sc_1 extending to a short distance beyond origin of Rs; male hypopygium complex in structure.

Male, length, 4.5 millimeters; wing, 4.5 to 5. Female, length, 5 millimeters; wing, 5.5.

Rostrum and palpi dark brown. Antennæ with scape and basal segments of flagellum light yellow; remainder of flagellum dark brown. Head ash gray. Pronotum and mesonotum light ash gray, prescutum with two intermediate pale brown stripes, pseudosutural foveæ large, pale brown, reaching margin of intermediate brown stripe; humeral region and lateral margins narrowly obscure yellow; scutum ash gray, lobes slightly darkened; scutellum brown; postnotum ash gray, the posterior margin darkened. Pleura pale brown, with an obscure yellow, longitudinal stripe extending from behind fore coxæ to beneath halteres, this stripe sometimes less distinct than in the typical form. Halteres pale. Legs with coxæ and trochanters pale brown; femora and tibiæ brownish testaceous, tips slightly darkened, tarsi dark brown. Wings with a yellowish tinge; stigma subcircular in outline, brown, ill defined; veins pale brown, cord and basal deflection of Cu_1 conspicuously dark brown. Venation: Sc_1 ending a short distance beyond origin of Rs; Rs a little shorter than in *G. pruinosa* Alexander (Formosa). Abdomen dark brown, the caudal margins of segments narrowly pale yellow; sternites and hypopygium obscure yellow. Male hypopygium very complex in structure; lateral apical angle of basistyle produced caudad into a moderately elongate, fleshy lobe; mesal apical angle slightly produced; dististyles four in number, more or less connected basally; the longest style a conspicuous flattened blade, near base on the mesal face sending off a curved arm that is directed caudad, expanded into a blackened head at apex, the mesal end of head a straight spine, the lateral end a longer, strongly curved spine; the next longest style is a slender blade, the distal two-thirds blackened; at about two-thirds the length on the mesal face with a short, sharp spine, apex beyond this sinuous and gradually narrowed to the acute apex; the other styles are a short, straight, blackened spine and a somewhat longer, straight, fleshy, sparsely setiferous lobe, both of these styles directed caudad. Ædeagus fleshy, the short apical points decurved, the dorsal surface setiferous.

Habitat.—Japan (Hokkaido and Honshiu).

Holotype, male, Jozankei, Hokkaido, August 19, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotypes, 5 males and females; paratypes, 4 males and females, Koiwai Farm, near Morioka, northern Honshiu, August 15 to September 2, 1920 (*C. Teranishi*).

Gonomyia (Ptilostena) sachalinensis sp. nov.

Female, length, 5.2 millimeters; wing, 6.5.

Generally similar to *G.* (*P.*) *subpruinosa* sp. nov., differing as follows:

Size larger. Head light yellow. Pronotum yellow. Mesonotal prescutum with disk almost covered by four confluent brownish gray stripes, the humeral region and broad lateral margins of sclerites pale yellow; mediotergite of postnotum dark brown, a small area at each anterolateral angle yellow. The yellow pleural stripe broader and more distinct. Wings with stigma lacking; veins all uniformly pale brown. Venation: Sc long, Sc_1 ending opposite midlength of the long, gently arcuated Rs, Sc_2 opposite origin of Rs; R_3 long, running generally parallel to R_{4+5}, cell R_3 at wing margin less than one-half cell R_2; cell 2d M_2 deep, about twice its petiole.

Habitat.—Japan (Saghalien).

Holotype, female, Toyohara, July 24, 1922 (*T. Esaki*).

Gonomyia (Lipophleps) flavo costalis sp. nov.

General coloration dark brown and yellow; pleura with a longitudinal yellowish white or white stripe; wings pale brown, variegated with subhyaline, the costal margin light yellow; Sc short, cell 1st M_2 closed, basal deflection of Cu_1 at its fork.

Male, length, 3.3 millimeters; wing, 3.5. Female, length, 3.8 millimeters; wing, 3.7.

Male.—Rostrum and palpi black. Antennæ with the basal segments orange, flagellum black, segments with elongate verticils. Head yellow, center of vertex with a brown spot. Pronotum sulphur yellow. Mesonotal prescutum largely covered by three confluent grayish brown stripes, the lateral margin narrowly sulphur yellow; pseudosutural foveæ surrounded by an ocherous triangle; scutum grayish brown; scutellum and postnotum yellow, the caudal margin of the latter darkened. Pleura brown with a conspicuous, yellowish white longitudinal stripe passing beneath base of halteres; sternopleura plumbeous. Halteres pale, knobs sulphur yellow. Legs with fore coxæ sulphur yellow, the other coxæ ocherous yellow; trochanters ocherous; femora obscure brownish yellow with a subterminal brown ring; tibiæ and tarsi pale brown, the terminal tarsal segments darker. Wings faintly tinged with brown, handsomely variegated with subhyaline spots and blotches; cells C and Sc light yellow, more whitish basally; stigma oval, dark brown; veins dark brown; the subhyaline areas include the prearcular region; spots before and beyond stigma; a transverse band before cord, cell 1st M_2, and smaller and more diffuse areas elsewhere on disk; veins pale brown. Venation: Sc short, Sc_1 ending a distance before origin of Rs that is nearly as long as latter; cell 1st M_2 closed; basal deflection of Cu_1 at fork of M. Abdomen dark brown, the caudal margins of segments narrowly yellow. Hypopygium obscure reddish brown, the chitinized dististyles black.

Female.—Generally similar to male, differing as follows: Lateral margins of prescutum narrower, humeral region darker. Pale pleural stripe narrower and nearly white. Halteres with face of knobs faintly darkened. Brown subterminal ring on femora darker, preceded and followed by yellowish rings. Pale rings on abdominal segments narrower and more whitish.

Habitat.—Japan (Hokkaido).

Holotype, male, Jozankei, August 19, 1922 (*T. Esaki*).

Allotopotype, female.

Paratypes, 1 female, Kutchan, July 9, 1922 (*T. Esaki*), at light of train; 1 female, Shikaripetsu, August 26, 1922 (*T. Esaki*).

Genus **PARATROPESA** Schiner

Paratropesa SCHINER, Verh. Zool. bot. Ges. Wien 16 (1866) 932.

The restricted genus *Paratropesa* now includes seven species, all from Tropical America. It was a great surprise to find in the present collection a perfectly typical member of this otherwise characteristically Neotropical group.

Paratropesa esakii sp. nov.

General coloration shiny black and yellow; rostrum nearly as long as head; halteres black, knobs orange yellow; femora yellow, the enlarged tips black; wings faintly tinged with yellow, sparsely variegated with brown.

Male, length, 6 millimeters; wing, 7.5. Female, length, 6.5 millimeters; wing, 6.

Rostrum nearly as long as head, black; palpi black. Antennæ dark brown; second scapal segment and base of first flagellar segment obscure yellow or yellowish brown. Head black, the anterior part of vertex sparsely pruinose; front yellow. Pronotum shiny yellow, narrowly darkened medially. Mesonotal prescutum shiny yellow, with three confluent, shiny black stripes that cover the entire sclerite except a small median area at suture, conspicuous triangular humeral areas and small spots at lateral ends of suture; scutum light yellow, each lobe almost covered by a shiny black area that is confluent with the prescutal marking; median sclerite of scutellum yellow; postnotum black. Pleura yellow; a conspicuous circular black spot on the dorsal pleurites ventro-cephalad of wing root; sternopleura faintly darkened. Halteres black, knobs conspicuously orange yellow. Legs with coxæ and trochanters yellow; femora obscure yellow, tips swollen and extensively blackened, these broadest on fore femora where about two-fifths of segment is included, narrowest on the posterior femora where the distal fifth is blackened; tibiæ brownish yellow, base narrowly, tip more broadly blackened; metatarsi black, base paler; remainder of tarsi black. Wings faintly tinged with yellow, base brighter; stigma small, suboval, dark brown; narrow brown seams at Sc_2, along cord and outer end of cell 1st M_2, along R_2, at tips of longitudinal veins and at apex of wing; veins black. Venation: Sc_1 ending nearly opposite midlength of Rs, Sc_2 a short distance beyond origin of Rs; R_2 about one-third R_3; cell 1st M_2 elongate, gently widened distally; basal deflection of Cu_1 about one-half its length beyond fork of M. Abdomen black, the incisures of tergites yellow, this including the extreme base and apex of each segment; hypopygium black; sternum yellow, sternites 2 to 4 with a blackish subterminal ring; segment 5 black, hairy as in this group. In female, abdomen black, the caudal margins of segments narrowly yellow; tergal valves of ovipositor obscure orange.

Habitat.—Japan (Hokkaido).

Holotype, male, Maruyama, August 17, 1922 (*T. Esaki*).

Allotype, female, Jozankei, August 19, 1922 (*T. Esaki*).

Paratopotypes, 3 males; paratype, 1 male, Abashiri, August 31, 1922 (*T. Esaki*).

The discovery of a species of *Paratropesa* in Japan is of exceptional interest. The present species is a true *Paratropesa*, the other Old World species hitherto placed in this genus being more correctly referable to *Gymnastes* Brunetti. This handsome little fly is named in honor of the collector, Dr. Teiso Esaki, who has done much toward making known the interesting tipulid fauna of Japan.

Genus **TEUCHOLABIS** Osten Sacken

Teucholabis OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 222.

The genus *Teucholabis* includes more than fifty species, the great majority of which are from Tropical America. A few species occur in the Old World, mostly in the Oriental Region. The present species, *Teucholabis yezoensis* sp. nov., is the most northerly species so far discovered, with the possible exception of the Nearctic *T. complexa* Osten Sacken.

Teucholabis yezoensis sp. nov.

General coloration shiny yellow and black; halteres with knobs orange yellow; legs black, the femoral bases yellow; wings subhyaline, stigma small, oval, brown; cell 1st M_2 long and narrow.

Male, length, 7 millimeters; wing, 6.2 to 6.4. Female, length, 8.2 millimeters; wing, 6.3 to 6.4.

Rostrum about as long as head, black; palpi black. Antennæ black, the basal segments paler. Head black, sparsely pruinose anteriorly. Pronotum shiny yellow, indistinctly darkened medially. Mesonotal prescutum shiny yellow with three confluent shiny black stripes that cover the entire sclerite excepting a small median area at suture, the lateral ends of suture, and larger, triangular humeral areas; scutum yellow, the lateral margins of lobes shiny black; scutellum honey yellow; postnotum black. Pleura yellow; a small and indistinct shiny black area on the dorsopleural region immediately cephalad of the lateral ends of suture. Halteres black, knobs orange yellow. Legs with coxæ and trochanters yellow, femora black, bases broadly and conspicuously yellow, narrowest on forelegs where a little less than one-half of the segment is included, broadest on hind legs where about two-thirds of segment is included; tibiæ pale brown, blackish at base and apex; basitarsi brown, tips and remainder of tarsi black. Wings subhyaline; stigma small, oval, brown; veins dark brown. Venation: Sc_1 ending before or near midlength of Rs; Sc_2 a short distance beyond origin of Rs; r about its own length from tip of R_1 and a short distance beyond fork of Rs; cell 1st M_2 long and narrow, gently widened distally, a little longer than vein M_3 beyond it; basal deflection of Cu_1 about one-half to one-third its length beyond fork of M. Abdomen black, incisures of tergites rather broadly yellowish; sternites yellow, faintly darkened laterally; the fifth sternite black and hairy; hypopygium brownish black.

Habitat.—Japan (Hokkaido).

Holotype, male, Shikaripetsu, August 26, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotypes, 1 male and 1 female.

Teucholabis yezoensis bears a striking superficial resemblance to *Paratropesa esakii* sp. nov.

Genus **NEOLIMNOPHILA** Alexander

Neolimnophila ALEXANDER, Proc. Calif. Acad. Sci. (4) 10 (1920) 37, 38.

The genus *Neolimnophila* was erected for the supposed Hexatomine *Limnophila ultima* Osten Sacken. Recent studies on the tribe Claduraria have indicated that the present group is more properly referable to the Eriopterini than to the Hexatomini, and that the closest relative of the present group is *Crypteria* Bergroth.

Neolimnophila ultima (Osten Sacken) var.

Limnophila ultima OSTEN SACKEN, Proc. Acad. Nat. Sci. Phila. (1859) 238, pl. 4, fig. 26.

Two females, from Toyohara, Saghalien, July 17, 1922 (*T. Esaki*), are referred to this Nearctic species, as a variety.

Genus **CONOSIA** van der Wulp

Conosia VAN DER WULP, Tijdsch. v. Ent. 23 (1880) 159.

The genotype *Conosia irrorata* (Wiedemann) has a vast range over the tropical and subtropical regions of the Old World. In the present collection it is represented by material from Hokkaido, which seems to be the most northern station so far discovered.

Conosia irrorata (Wiedeman).

Limnobia irrorata WIEDEMANN, Aussereur. zweifl. Ins. 1 (1828) 574.

One female from Kamuikotan, Hokkaido, August 22, 1922 (*T. Esaki*).

Subfamily CYLINDROTOMINÆ

Genus **CYLINDROTOMA** Macquart

Cylindrotoma MACQUART, Hist. Nat. Ins., Dipt. (1834) 107.

Cylindrotoma japonica Alexander.

Cylindrotoma japonica ALEXANDER, Ann. Ent. Soc. Am. 12 (1919) 344, 345.

This was the only member of the subfamily taken by Doctor Esaki upon his northern trip. The fly was known hitherto only from Honshiu. The following additional records are available:

Saghalien: Takinosawa, July 26, 1922; Shimizu, July 27, 1922. Hokkaido: Kamiotoineppu, August 24, 1922; Shikaripetsu, August 26, 1922; Akan, September 3, 1922.

Genus **NESOPEZA** Alexander

Nesopeza ALEXANDER, Can. Ent. 46 (1914) 157.

Nesopeza geniculata Alexander.

Nesopeza geniculata ALEXANDER, Ann. Ent. Soc. Am. 11 (1918) 448, 449.

One male, Abashiri, Hokkaido, August 30, 1922 (*T. Esaki*). The species had been recorded from Honshiu and Kiushiu.

Genus **OROPEZA** Needham

Oropeza NEEDHAM, 23d Rept. N. Y. St. Ent. for 1907 (1908) 211.

The genus *Oropeza* furnishes a strong point of evidence regarding the close relationship existing between the fauna and flora of Japan and those of eastern North America, well shown in many groups of animals and plants. The genus, as at present known, includes eight American species, all from the eastern United States and Canada, and three additional species from Japan, one occurring in Formosa.

Oropeza satsuma Alexander.

Oropeza satsuma ALEXANDER, Journ. N. Y. Ent. Soc. 26 (1918) 67.

Saghalien: Toyohara, July 16, 1922 (*T. Esaki*). Hokkaido: Sapporo, August 21, 1922; Kamiotoineppu, August 23, 1922 (*T. Esaki*).

Genus **TANYPTERA** Latreille

Tanyptera LATREILLE, Hist. Nat. Crust. et Ins. 14 (1805) 286.
Xiphura BRULLE, Ann. Soc. Ent. France 1 (1832) 206.

Tanyptera jozana (Matsumura) var.

Xiphusa jozana MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 450, 451, pl. 24, fig. 13.

Saghalien: Toyohara, July 13 to 16, 1922 (*T. Esaki*); Konuma, July 22, 1922 (*T. Esaki*).

The typical variety was described from Hokkaido, and is now known also from Honshiu. The present form is presumably the one recorded by Matsumura from Solowiyofka, Saghalien (1911: 62) under the name *Xiphura macra* Loew, which is now considered a synonym of *Tanyptera gracilis* (Portschinsky).

Genus CTENOPHORA Meigen

Ctenophora MEIGEN, Illiger's Mag. 2 (1803) 263.

Ctenophora biguttata Matsumura.

Ctenophora biguttata MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 454, 455, pl. 24, fig. 16.

One female, Manui, Saghalien, August 3, 1922 (*T. Esaki*).

Known hitherto only from the vicinity of Sapporo (the type locality) and from northern Teshio, Hokkaido.

Genus NEPHROTOMA Meigen

Nephrotoma MEIGEN, Illiger's Mag. 2 (1803) 262.
Pachyrrhina MACQUART, Hist. Nat. Ins., Dipt. 1 (1834) 88.

The genus *Nephrotoma* is abundantly represented in all parts of the Japanese Empire. The present collection included eight species.

Nephrotoma esakii sp. nov.

General coloration shiny black; head orange above; knobs of halteres sulphur yellow; legs with fore femora largely black; tibiæ yellow, tips narrowly dark brown; wings with a yellowish tinge, apex narrowly seamed with brown; valves of ovipositor orange, relatively short and small.

Female, length, about 10 millimeters; wing, 12.

Frontal prolongation of head, palpi, and mouth parts black. Antennæ with scape and basal segment of flagellum orange yellow; intermediate flagellar segments with bases paler than apices; terminal segments of antennæ dark brown. Head orange yellow, the occipital band shiny black; genæ and beneath dull black. Pronotum black. Mesonotal prescutum shiny black, the usual interspaces very narrowly yellow, these capillary lines attaining suture but not reaching the anterior end of sclerite; scutum yellow, lobes largely black; scutellum and postnotum black. Pleura black, the dorsopleural membrane buffy; a very obscure, paler brown area before root of halteres. Halteres brown, the knobs conspicuously sulphur yellow. Legs with coxæ black; trochanters yellow; femora yellow, tips broadly blackened, fore femora black with the exception of narrow, obscure yellow bases; tibiæ abruptly yellow, tips narrowly dark brownish black; basitarsi brownish yellow, passing into black; remainder of tarsi black. Wings strongly tinged with yellow, base and cells C and Sc more saturated yellow; stigma oval, pale brown; wing apex very narrowly margined with dark brown; veins dark brown, very narrowly seamed with brown. Venation: Rs only a little longer than the basal deflection of R_{4+5}; cell M_1 rather broadly sessile; fusion of Cu_1 and M rather extensive, ending at fork of M. Abdomen black, the intermediate segments with a large, obscure yellow area on either side of the capillary median black stripe; segments 5 to 8 shiny black. Ovipositor with the valves relatively short and small, obscure orange. The somewhat similar *Nephrotoma stygia* Alexander has the valves of the ovipositor of normal length.

Habitat.—Japan (Hokkaido).

Holotype, female, Kamiotoineppu, August 25, 1922 (*T. Esaki*).

This handsome species is named in honor of the collector, Dr. Teiso Esaki, to whom we are indebted for almost our sole knowledge of the tipulid fauna of northern Hokkaido and Saghalien.

Nephrotoma dorsalis sachalina subsp. nov.

Male, length, about 11 millimeters; wing, 12.8 to 13.

Generally similar to *N. dorsalis* Meigen (Europe), differing as follows:

Lateral margins of pronotal scutum conspicuously blackened. Femoral apices more extensively infuscated. Brown cloud on basal deflection of R_{4+5} and r-m more extensive. Male hypopygium largely black instead of obscure brownish yellow; outer dististyle near midlength produced into a very slender, attenuate point, slenderer than in typical *dorsalis.*

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 16, 1922 (*T. Esaki*).

Paratopotype, male.

Nephrotoma hirsuticauda sp. nov.

General coloration orange, prescutum and scutum with black stripes; wings tinged with pale yellow, base and cell Sc brighter yellow; abdomen orange, the lateral margins of tergites interruptedly darkened; eighth sternite of male hypopygium large. deeply incised medially, incision clothed with dense, long, yellow setae.

Male, length, 10 millimeters; wing, 9 to 9.2. Female, length, 13 millimeters; wing, 11.4.

Frontal prolongation of head obscure yellow, nasus darker; mouth parts and palpi pale brown. Antennæ rather short, if bent backward not extending far beyond root of wing; basal three segments obscure orange, remainder of organ black. Head orange, the occipital band conspicuous, brown. Pronotum obscure yellow. Mesonotal prescutum shiny yellow with three black stripes; in the type, these stripes are much paler, except at the anterior ends; lateral stripes very strongly and conspicuously outcurved, scutal lobes conspicuously marked with black, in the type with only the ends of these marks blackened; scutellum orange testaceous; postnotum orange. Pleura obscure orange, indistinctly variegated with obscure yellow, this including a conspicuous mark between bases of wings and halteres. Halteres pale brown, apices of knobs yellow. Legs with coxæ and trochanters obscure yellow; femora and tibiæ pale brown, tips narrowly blackened; tarsi brownish black. Wings tinged with pale yellow, base and cell Sc brighter yellow; stigma small, pale brown; veins dark brown. Venation: Rs short, in alignment with deflection of R_{4+5}, shorter than R_{2+3}; r-m short; cell M_1 narrowly sessile. Abdomen orange, the lateral margins of tergites with brown markings, more or less interrupted at base of segments; in the Mount Moiwa paratype, this coloration extends across the caudal margin of tergite 7; hypopygium orange. Male hypopygium obliquely truncated, the ventral surface of the extensive eighth sternite with conspicuous long yellow setæ, these decussate across a deep median incision; lobes of ninth sternite likewise with shorter but conspicuous yellow setæ.

Habitat.—Japan (Saghalien and Hokkaido).

Holotype, male, Sapporo, Hokkaido, July, 1921 (*S. Kuwayama*).

Allotype, female, Toyohara, Saghalien, July 20, 1922 (*T. Esaki*).

Paratypes, 1 male, Mount Moiwa, near Sapporo, Hokkaido, July 15, 1921 (*M. Hori*) ; 3 males and females, with the allotype, July 20 to 23, 1922 (*T. Esaki*).

Nephrotoma hirsuticauda somewhat resembles *N. geminata* Alexander (Honshiu), differing in the coloration and structure of the male hypopygium.

Nephrotoma minuticornis Alexander.

Nephrotoma minuticornis ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 134.

The type locality is Sapporo. The present collection includes the following material.

Saghalien: Toyohara, July 16, 1922 (*T. Esaki*). Hokkaido: Sapporo, August 17, 1922; Jozankei, August 19, 1922; Kamuikotan, August 22, 1922; Kamiotoineppu, August 24, 1922; Kamiokoppe, August 27, 1922; Setoughi, August 28, 1922; Abashiri, August 31, 1922; Tsubetsu, September 1, 1922; Ponkikin, September 2, 1922 (*T. Esaki*).

Nephrotoma aculeata atricauda subsp. nov.

Male, length, 12 millimeters; wing, 13. Female, length, 14 millimeters; wing, 13.5.

Generally similar to typical *aculeata* (Loew) of Europe, differing as follows: Body heavier, including hypopygium. Male hypopygium shiny black, appendages larger and more prominent. Aculeate spine on eighth sternite stouter and more strongly curved.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, August 8, 1922 (*T. Esaki*).

Allotopotype, female.

Paratopotype, male.

Nephrotoma cornicina (Linnæus) var.

Tipula cornicina LINNÆUS, Syst. Nat., ed. 10 (1758) 586.

This species had already been recorded from Honshiu. Doctor Esaki's material adds the following records of distribution:

Saghalien: Maoka, July 29, 1922 (*T. Esaki*). Hokkaido: Sapporo, July 10 to August 16, 1922; Jozankei, August 19, 1922; Kamiotoineppu, August 24, 1922; Abashiri, August 31, 1922 (*T. Esaki*).

Nephrotoma lamellata (Riedel) var.

I can detect no essential differences between the Japanese specimens and Riedel's description of this European species. The present collection includes the following records:

Saghalien: Shimizu, July 27, 1922; Maoka, July 28, 1922; Todorokitôge, August 2, 1922 (*T. Esaki*).

Nephrotoma parvirostra sp. nov.

General coloration yellow; occiptal band very small to subobsolete; lateral ends of transverse suture blackened; abdomen orange, tergites with an interrupted median stripe; eighth sternite of male hypopygium with a small, prow-shaped median lobe.

Male, length, 11 to 11.5 millimeters; wing, 11 to 11.5.

Frontal prolongation of head yellow, the elongate nasus brown; palpi pale brown, the terminal segment yellow, narrowly tipped with brown. Antennæ rather short, if bent backward extending to beyond wing root; first scapal segment bright yellow; segments 2 and 3 light brown; remaining segments dark brownish black, covered with a dense microscopic pubescence. Head orange, the vertical tubercle light sulphur yellow; occipital band very small to subobsolete, pale brown, the anterior end truncate. Pronotum sulphur yellow. Mesonotum light yellow, prescutum with three black stripes, the lateral stripes with a dark spot at their anterior ends, producing the appearance of being outcurved; scutal lobes similar, very extensively marked with black, the color following along suture to wing root; scutellum pale brownish testaceous; postnotum whitish yellow, the caudal margin of the median sclerite with two pale brown areas. Pleura pale reddish brown, variegated with pale yellow, the latter color including a conspicuous area on the lateral sclerites of postnotum between bases of wings and halteres. Halteres pale brown, base of stem and knobs yellow. Legs with coxæ and trochanters yellow; femora pale brown; tibiæ pale brown, narrowly tipped with dark brown; tarsi dark brown. Wings with a pale brown tinge; stigma rather light brown; a very indistinct seam along the basal deflection of R_{4+5} and r-m; veins dark brownish black. Venation: Cell M_1 subsessile or very short-petiolate. Abdomen obscure orange, tergites with a median series of black areas on the posterior half of tergites 2 to 6; tergite 7 more extensively blackened; tergites 8 and 9 and hypopygium orange; eighth sternite black on basal half. Male hypopygium with the median portion of the caudal margin of the eighth sternite produced into a small, prow-shaped lobe, this very compressed and covered with an appressed yellow pubescence, directed caudad, tip ventrad.

Habitat.—Japan (Hokkaido).

Holotype, male, Sapporo (*M. Hori*).

Paratopotype, male, July 25, 1921 (*S. Kuwayama*); paratypes, male, Shikaripetsu, August 26, 1922 (*T. Esaki*); male, Kamiokoppe, August 27, 1922 (*T. Esaki*).

Genus **TIPULA** Linnæus

Tipula LINNAEUS, Syst. Nat. ed. 10 (1758) 585.
Nippotipula MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 457, 458.
Platytipula MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 459.
Yamatotipula MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 461, 462.
Togotipula MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 465.

The great genus *Tipula* is abundantly represented in the Japanese Empire. The present collection included representatives of eighteen species, seven of which are considered as being undescribed.

Tipula coquilletti Enderlein.

Tipula nubifera COQUILLET, Proc. U. S. Nat. Mus. 21 (1898) 305; preoccupied by *Tipula nubifera* van der Wulp (1881).
Tipula coquilletti ENDERLEIN, Zool. Jahrb., Syst. 32 (1912) 7.

This is the largest and handsomest species of the genus in Japan. It ranges from Saghalien southward to the mountains of Taiwan. The Esaki material includes the following:

Saghalien: Kiminai, August 12, 1922. Hokkaido: Kamiokoppe, August 27, 1922; Panketo, September 6, 1922; Maruyama, September 17, 1922.

Tipula moiwana (Matsumura).

Platytipula moiwana MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 458, 459, pl. 25, fig. 2.

This beautiful late summer and autumnal species bears a resemblance to the Nearctic *T. ultima* Alexander. It was described from Mount Moiwa and other stations near Sapporo. Doctor Esaki's collections include the following records:

Hokkaido: Kamiotoineppu, August 25, 1922; Shikaripetsu, August 26, 1922; Kamiokoppe, August 27, 1922; Abashiri, August 31, 1922; Akan, September 4 to 7, 1922; Sapporo, September 26, 1922.

Tipula nova Walker.

Tipula nova WALKER, List Dipt. Brit. Mus. 1 (1848) 71.
Yamatotipula nohirae MATSUMURA, Thous. Ins. Japan, Add. 2 (1916) 461, pl. 25, fig. 4.

This species has a very wide range over eastern and southern Asia. Doctor Esaki secured the species in two places in

Hokkaido: Kamiotoineppu, August 25, 1922; Shitakara, September 10, 1922.

Tipula variicornis Schummel.

Tipula variicornis SCHUMMEL, Beitr. zur Entomol. 3 (1833) 99, pl. 3, figs. 2, 3.

Tipula annulicornis MEIGEN, Syst. Beschr. 6 (1830) 289, pl. 65, fig. 9; preoccupied by *T. annulicornis* Say (1829).

This familiar European species was taken by Doctor Esaki at Toyohara, Saghalien, July 13 to 21, 1922. It had previously been recorded from Tonnaitcha, Saghalien, by Matsumura (1911) under the name *Pachyrrhina annulicornis* Meigen.

Tipula latemarginata Alexander.

Tipula latemarginata ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 128, 129.

This species is related to *T. marginata* Meigen of Europe. Some of the Hokkaido specimens recorded below are larger and with a heavier wing pattern than in typical examples, but undoubtedly belong here. The following material was secured by Doctor Esaki:

Saghalien: Konuma, July 17, 1922; Toyohara, July 25, 1922; Takinosawa, July 26, 1922; Shimizu, July 27, 1922; Manui, August 3, 1922; Odasam, August 5, 1922; Kiminai, August 12, 1922. Hokkaido: Maruyama, August 17, 1922; Jozankei, August 19, 1922; Kamuikotan, August 23, 1922; Kamiotoineppu, August 24, 1922; Shikaripetsu, August 26, 1922; Abashiri, August 31, 1922; Ponkikin, September 2, 1922.

Tipula fumida sp. nov.

General coloration gray, prescutum with three dark brown stripes; wings strongly tinged with brown, with obliterative areas before stigma and across base of cell 1st M_2; male hypopygium with the caudal margin of the ninth tergite produced into a blunt median lobe, apex of which is blackened and feebly bilobed.

Male, length, 12 millimeters; wing, 14.5.

Frontal prolongation of head obscure brownish yellow, light gray above; nasus elongate; palpi brownish black. Antennæ rather short, scape and two basal segments of flagellum brown, the terminal flagellar segments darker brown to almost black. Head dark gray, the median area darker. Pronotum dark gray, the scutellar angles light yellow. Mesonotal prescutum gray with three dark brown stripes, the median stripe split by a capillary dark brown vitta; scutellum and postnotum dark brownish gray. Pleura gray, darker on the anterior pleurites; dorsopleural membrane buffy. Halteres light brown. Legs with coxæ pale; trochanters obscure yellow; femora and tibiæ brownish yellow, tips narrowly but conspicuously blackened, this amount subequal on all legs; tarsi black, basitarsi paler proximally. Wings strongly tinged with brown, base more yellowish; stigma slightly darker brown; conspicuous obliterative areas before stigma and across base of cell 1st M_2; veins dark brown. Venation: Rs long, more than twice R_{2+3}; R_2 entire; r relatively short; cell 1st M_2 gently narrowed distally; petiole of cell M_1 longer than m; m-cu at about one-fifth the length of cell 1st M_2; cell 2d A relatively narrow. Abdominal tergites obscure yellow, on either side with a broad, conspicuous, dark stripe, the lateral margins and median area broadly of ground color; caudal margins of segments narrowly pale; sternites dark brown, the terminal segments more pruinose; caudal margins of sternites narrowly ringed with pale; hypopygium rather pale. Male hypopygium with the caudal margin of the ninth tergite produced into a median lobe as in *T. latemarginata* Alexander and allies, apex feebly bilobed, blackened. Outer diststyle a pale, flattened lobe. Eighth sternite unarmed.

Habitat.—Japan (Hokkaido).

Holotype, male, Kushiro, September 11, 1922 (*T. Esaki*).

Tipula bipenicillata sp. nov.

Male, length, 16 to 17 millimeters; wing, 17 to 18. Female, length, 22 millimeters; wing, 18.

Rather closely resembling *T. saitamæ* Alexander, differing in the details of coloration and the structure of the male hypopygium.

Femoral tips conspicuously and broadly dark brown; tibial apices extensively blackened. Wings more grayish; cell Sc and stigma infuscated; obliterative areas passing from cell 1st R_1 before stigma into cell 1st M_2. Abdomen with segments 6 to 9 black, the caudal margins of segments narrow, the lateral margins of tergites more broadly pale. Male hypopygium with the caudal margin of the eighth sternite unarmed except for a conspicuous pencil or rather short golden setæ on either side.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 23, 1922 (*T. Esaki*).

Allotype, female, Konuma, July 21, 1922 (*T. Esaki*).

Paratopotype, male, July 25, 1922; paratypes, 2 males, with the allotype; 1 male, Shimizu, July 27, 1922 (*T. Esaki*).

Tipula saitamæ Alexander.

Tipula saitamæ ALEXANDER, Trans. Amer. Ent. Soc. 46 (1920) 21, 22.

One male, Abashiri, Hokkaido, August 30, 1922 (*T. Esaki*).

Tipula insulicola fuscicauda subsp. nov.

Male, length, 10 millimeters; wing, 12.5. Female, length, 11 to 12 millimeters; wing, 11.5 to 12.

Close to the typical subspecies, differing in the larger and stouter hypopygium of the male which is conspicuously brownish black, the longer median process of the ninth tergite yellow. Wing membrane more grayish yellow.

Habitat.—Japan (Saghalien).

Holotype, male, Manui, August 3, 1922 (*T. Esaki*).

Allotopotype, female.

Paratypes, 1 male, Toyohara, July 21, 1922 (*T. Esaki*), at honey bait trap; 2 females, July 25, 1922 (*T. Esaki*).

Tipula nipponensis Alexander.

Tipula nipponensis ALEXANDER, Can. Ent. 46 (1914) 236, 237.

Saghalien: Toyohara, July 21, 1922, at honey bait trap; Konuma, July 21, 1922; Takinosawa, July 26, 1922; Nodasam, July 30, 1922 (*T. Esaki*). Hokkaido: Kamiotoineppu, August 23, 24, 1922 (*T. Esaki*).

The radial sector is shorter than in the type but the species is almost certainly identical.

Tipula westwoodiana sp. nov.

Size large (wing, over 25 millimeters); general coloration gray, prescutum with four brown stripes; wings with a strong yellowish tinge, base and cells C and Sc more saturated; stigma brown; abdominal tergites obscure yellow with two sublateral brown stripes on either side.

Female (?), length of wing, 26.8 millimeters.

Frontal prolongation of head dark; nasus elongate; palpi with basal two segments black, the terminal two yellow, with the extreme tip of the last darkened. Antennæ with the scape yellow, the flagellar segments brown. Head dark, sparsely pruinose; vertex flattened, the usual tubercle represented only by a tiny protuberence behind each antennal fossa. Mesonotal prescutum dull gray with four brown stripes; humeral triangle reddish brown; scutum light gray, each lobe with a circular brown mark; scutellum with the median lobe dark, dusted with gray, the lateral lobes variegated with pale; postnotum with mediotergite black, dusted with gray. Pleura dark brown, discolored in type, presumably gray pruinose in fresh specimens; pleurotergite with a yellowish semicircle surrounding root of halteres. Halteres brownish yellow. Legs with coxæ dark, presumably pruinose in fresh specimens, apices paler; trochanters obscure yellow; femora obscure yellow basally, tips conspicuously blackened, on forelegs including the distal two-thirds, on the posterior femora only the broad tips are blackened; tibiæ brown, tips darker; tarsi brownish black. Wings with a strong yellowish tinge, base and cells C and Sc saturated; stigma oval, brown; brown seams along cord and more narrowly on the longitudinal veins beyond cord; veins black, paler in the flavous areas. Venation: Rs long; R_2 distinct for its entire length; r with macrotrichiæ throughout its length; petiole of cell M_1 about one-half m; m-cu short but distinct. Abdominal tergites obscure yellow, the lateral margins buffy, margined internally by a more or less distinct brown stripe; median line of tergite broadly obscure yellow, bordered on either side by a broad, sublateral, dark brown stripe; on the subterminal segments the dark stripes become confluent; sternites brownish yellow; tip of abdomen broken in the unique type.

Habitat.—Japan (Saghalien).

Holotype, sex ?, Shimizu, July 27, 1922 (*T. Esaki*).

Tipula coquillettiana sp. nov.

Belongs to the *centralis* group; male hypopygium with the ninth tergite rather narrow, the caudal margin elevated into a narrow, erect, chitinized rim that is feebly denticulate.

Male, length, 16 millimeters; wing, 18.

Frontal prolongation of head reddish brown, gray above; nasus elongate; palpi black. Antennæ relatively short; scape obscure yellow, the first segment a little darkened basally; flagellum dark brown, the basal swellings moderate in size. Head gray, clearer posteriorly. Mesonotal prescutum light gray with four darker gray stripes, each of which is narrowly bordered by brown; scutum light gray, lobes largely dark gray; scutellum and postnotum light gray. Pleura gray; dorsopleural membrane buffy. Halteres obscure brownish yellow, knobs dark brown. Legs with coxæ gray; trochanters obscure yellow; femora brownish yellow, tips broadly dark brown; tibiæ brown, tips very indistinctly darker; tarsi brown, the terminal segments passing into dark brown. Wings of the general type of *T. kuwayamai* Alexander and related species; whitish subhyaline, base and costal region more yellowish; stigma small, preceded by an eyelike brown spot; pale brown clouds on surface, the white pattern correspondingly restricted, including a narrow band beyond the cord extending through cell 1st M_2 into M_3; bases of cells R and M; a large blotch near two-thirds the length of cell M; and base and apex of cell 1st A; outer end of cell R_5 pale; bases of cells R and M not darkened; veins dark brown. Abdomen with the basal segment pruinose; segment 2 yellow, the lateral margins ocherous, sparsely pruinose; tergites 3 to 5 similar but becoming gradually darker colored; terminal segments and hypopygium dark brown, segments very narrowly ringed caudally with pale. Male hypopygium of the general type of *T. centralis* and related species. Ninth tergite rather narrow, the caudal margin elevated into a narrow, erect, chitinized rim, shiny black, the caudal margin nearly straight across but feebly denticulate, the lateral angles a little more conspicuous. Outer dististyle slender, clavate. Eighth sternite unarmed.

Habitat.—Japan (Saghalien).

Holotype, male, Odasam, August 5, 1922 (*T. Esaki*).

Paratopotype, male.

Tipula verecunda sp. nov.

Male, length, 13 to 14 millimeters; wing, 17. Female, length, 20 to 22 millimeters; wing, 17 to 19.

Generally similar to *T. coquillettiana* sp. nov., differing as follows:

Antennæ longer. Head light ocherous yellow with a capillary brown median vitta. Mesonotal prescutum paler with the four stripes darker brownish gray, narrowly and conspicuously margined with dark brown, the lateral stripes crossing suture onto the anterolateral regions of scutum; disk of scutal lobes with a larger brownish gray area, narrowly margined with darker; scutellum and postnotum gray with a narrow, dark brown, median line. Pleura dark gray, the dorsopleural membrane more buffy. Wings somewhat similar to *T. coquillettiana*, differing chiefly as follows: Bases of cells R and M darkened; the white band before midlength of cell 1st A continued across vein 1st A to wing margin in tip of cell 2d A; bases of anal cells more abruptly pale. Venation: Cell 1st M_2 smaller. Abdomen with tergites 2 to 4 light yellow, the lateral margins broadly pale, narrowly margined internally by a brownish black line; terminal segments uniformly dark brownish black with pale margins; sternites similar, the terminal segments dark pruinose. Male hypopygium with the ninth tergite extensive but not chitinized, the caudal margin with a deep U-shaped notch, surface with yellow setæ. Basistyle complete. Outer dististyle flattened, dark-colored. Ninth sternite produced ventrad into a small median tubercle. Eighth sternite unarmed caudally but surface with rather numerous long yellow setæ. Female with the valves of the type of *T. arctica* et al., but margins not serrate.

Habitat.—Japan (Saghalien).

Holotype, male, Toyohara, July 16, 1922 (*T. Esaki*).

Allotype, female, Shimizu, July 27, 1922 (*T. Esaki*).

Paratopotypes, 3 males and 1 female, July 13, 14, 1922; paratype, female, Nodasam, July 31, 1922.

Tipula tantula sp. nov.

General coloration gray, prescutum with four very indistinct darker gray stripes; femora brownish yellow, tips blackened; wings subhyaline, with a very pale, ill-defined brown pattern; male hypopygium with the ninth tergite having a V-shaped notch.

Male, length, 10.5 millimeters; wing, 11.

Frontal prolongation of head dark gray above, nasus apparently lacking or very rudimentary; palpi relatively short, black. Antennæ relatively short; scape and first flagellar segment obscure yellow; remainder of antenna dark brown; individual flagellar segments moderately incised. Head dull gray, with a capillary dark brown vitta. Mesonotal prescutum gray with four very indistinct darker gray stripes, the intermediate pair only narrowly separated from one another, strongly narrowed behind; scutum dark gray, centers of lobes faintly darkened; scutellum light gray with a capillary brown median vitta; postnotum gray with a capillary brown line. Pleura gray, indistinctly variegated with darker; dorsopleural membrane buffy. Halteres pale brownish white. Legs with coxæ light gray, paler apically; trochanters yellow; femora brownish yellow, tips narrowly but conspicuously blackened, the amount subequal on all the legs; tibiæ paler brown, tips very narrowly darker brown; tarsi black. Wings subhyaline, with a very pale brown, ill-defined pattern; stigma oval, darker brown; the subhyaline markings include areas before and beyond stigma, the latter forming an ill-defined crossband that follows through cell 1st M_2 into base of cell M_3; a blotch beyond midlength of cell M; a pale area in cell 1st A at tip of vein 2d A; less-distinct pale areas in the anal and cubital cells near base; veins brown. Venation: Rs very long; base of R_2 faintly indicated, perpendicular at origin; basal deflection of R_{4+5} short or lacking; cell 1st M_2 nearly pentagonal; petiole of cell M_1 more than twice m; m-cu obliterated by fusion of adjoining veins. Abdomen obscure yellow, the lateral margins of tergites narrowly buffy, margined internally by a narrow black line; segments 5 to 9 passing into black; sternites similar. Male hypopygium moderately incrassate. Ninth tergite with a broad V-shaped notch, at base of which is a microscopic tubercle. Outer dististyle slender, pale; inner dististyle a conspicuous compressed blade, the apical point jutting into notch of tergite. Ninth sternite with a deep V-shaped median notch. Eighth sternite unarmed.

Habitat.—Japan (Saghalien).

Holotype, male, Odasam, August 5, 1922 (*T. Esaki*).

Tipula matsumuriana sp. nov.

General coloration light gray, prescutum with four narrow pale brown stripes; pleura uniformly clear gray; femora obscure yellow, tips conspicuously blackened; wings whitish subhyaline, variegated with pale brown and yellow; a broad, nearly complete white crossband beyond cord.

Female, length, 19 millimeters; wing, 17.

Frontal prolongation of head elongate, dark brown beneath and on sides, yellow dorsally; nasus long and slender; palpi dark brown. Antennæ with scape and basal segments of flagellum yellow; remainder of antennæ dark brown. Head yellowish gray with a delicate, capillary, brown median vitta. Mesonotal prescutum light gray with four narrow, pale brown stripes, the intermediate pair narrowed posteriorly; pseudosutural foveæ reduced to a blackened puncture; scutum gray, lobes with very pale brown centers; scutellum pale gray, the lateral sclerites darker; postnotum clear light grey. Pleura uniformly clear gray; dorsopleural membranes whitish. Halteres yellow with conspicuous dark brown knobs. Legs with coxæ light gray; trochanters yellow; femora obscure yellow, tips rather narrowly but conspicuously blackened, these areas subequal on all the legs; tibiæ dark brown, bases pale; tarsi brownish black. Wings whitish subhyaline, base and cells C and Sc yellow; a conspicuous pale brown pattern occupies most of wing surface; stigma darker brown; the whitish ground color occupies the following areas: Before and beyond origin of Rs; a large area occupying the basal half of cell M; a semicircular area in cell M beneath origin of Rs and a smaller one at the outer end of cell; a very broad whitish crossband beyond cord, including the basal halves of cells R_2 and R_3; basal portion of R_5 and center of 1st M_2, passing into cells M_3 and Cu_1; outer half of cell R_5 faintly pale; pale areas in cell Cu at basal third and before apex, and in cell 1st A before midlength and at margin; bases of anal cells indistinctly paler; veins dark brown, yellowish in the costal and basal regions. Abdomen with the basal segments light yellow, the terminal segments passing into darker, surface dark gray pruinose; tergites with the lateral margins narrowly whitish, the caudal margins less distinctly so. Ovipositor with the slender valves with smooth margins.

Habitat.—Japan (Hokkaido).

Holotype, female, Jozankei, August 19, 1922 (*T. Esaki*).

Tipula bubo Alexander.

Tipula bubo ALEXANDER, Journ. N. Y. Ent. Soc. 26 (1918) 69, 70.

The type locality for this handsome fly is Honshiu. Doctor Esaki's material adds the following records:

Saghalien: Toyohara, July 14 to 23, 1922; Odasam, August 5, 1922. Hokkaido: Jozankei, August 19, 1922; Kamiotoineppu, August 23, 1922.

Tipula flavocostalis Alexander.

Tipula flavocostalis ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 124, 125.

Saghalien: Toyohara, July 13 to 18, 1922 (*T. Esaki*); Konuma, September 1, 1921 (*S. Kuwayama*).

The type locality is Honshiu and the species has not yet been taken in Hokkaido.

Tipula taikun Alexander.

Tipula taikun ALEXANDER, Ann. Ent. Soc. Am. 14 (1921) 125, 126.

Hokkaido: Kamuikotan, August 22, 1922; Kamiotoineppu, August 24, 25, 1922; Kamiokoppe, August 27, 1922; Setonshi, August 28, 1922; Abashiri August 31, 1922; Obihiro, Tokachi Province, September 12, 1922 (*T. Esaki*).

The type locality is Morioka, Iwate-Ken, Honshiu.

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ALEXANDER, CHARLES P. New species of Japanese crane-flies (Diptera, Tipulidæ) Part 2. Insec. Inscit. Menst. 9 (1921) 179 to 186.

The above works describe collections taken by Messrs. Isshiki, Kuwayama, and Shiraki in the provinces of Ishikari and Teshio.

MATSUMURA, S. Thousand Insects of Japan 2 (1905) 123, 124, Plate 29, figs. 5, 6.

Describes as new *Tipula longicauda* and *Ctenophora yezoana;* Japanese text only; figures excellent.

MATSUMURA, S. Erster Beitrag zur Insekten-Fauna von Sachalin. Journ. Coll. Agric. Tohoku Imp. Univ. 4 (1911) 1 to 145, Plates 1, 2.

Discussed in text of present paper.

MATSUMURA, S. Konchû Bunruigaku. Systematic entomology 2 (1915) 60 to 64, Plate 2, figs. 14 to 16.

Japanese text only; on page 63, fig. 15, records *Chionea araneoides* Dalman from vicinity of Sapporo.

MATSUMURA, S. Thousand Insects of Japan, Add. 2 (1916) 447 to 474, Plate 24, figs. 10 to 17, Plate 25, figs. 1 to 13.

Text in both Japanese and English; figures excellent.

ILLUSTRATIONS

[*a*= ædeagus; *b*= basistyle; *d*= dististyle; *g*= gonapophyses; *p* = proctiger; *t*= ninth tergite.]

PLATE 1

FIG. 1. *Dicranomyia subtristis* sp. nov., hypopygium.
2. *Dicranomyia megacauda* sp. nov., rostriform appendage.
3. *Dicranomyia megacauda* sp. nov., appendage of basistyle.
4. *Dicranomyia globulithorax* sp. nov., hypopygium.
5. *Dicranomyia spinicauda* sp. nov., hypopygium.
6. *Limonia angustistria* sp. nov., dististyles.
7. *Limonia basispina* sp. nov., hypopygium.
8. *Limonia monacantha* sp. nov., hypopygium.

PLATE 2

FIG. 9. *Antocha serricauda* sp. nov., hypopygium.
10. *Antocha bifida* sp. nov., hypopygium.
11. *Antocha brevistyla* sp. nov., hypopygium.
12. *Antocha brevinervis* sp. nov., hypopygium.
13. *Antocha satsuma* Alexander, hypopygium.
14. *Antocha dilatata* sp. nov., hypopygium.
15. *Erioptera sachalina* sp. nov., ninth tergite.
16. *Erioptera yezoana* sp. nov., ninth tergite.
17. *Erioptera sachalina* sp. nov., lateral lobe of tergite.
18. *Erioptera yezoana* sp. nov., lateral lobe of tergite.
19. *Erioptera sachalina* sp. nov., dististyle.
20. *Erioptera yezoana* sp. nov., dististyle.
21. *Erioptera flavohumeralis* sp. nov., hypopygium.
22. *Erioptera horii* sp. nov., hypopygium.

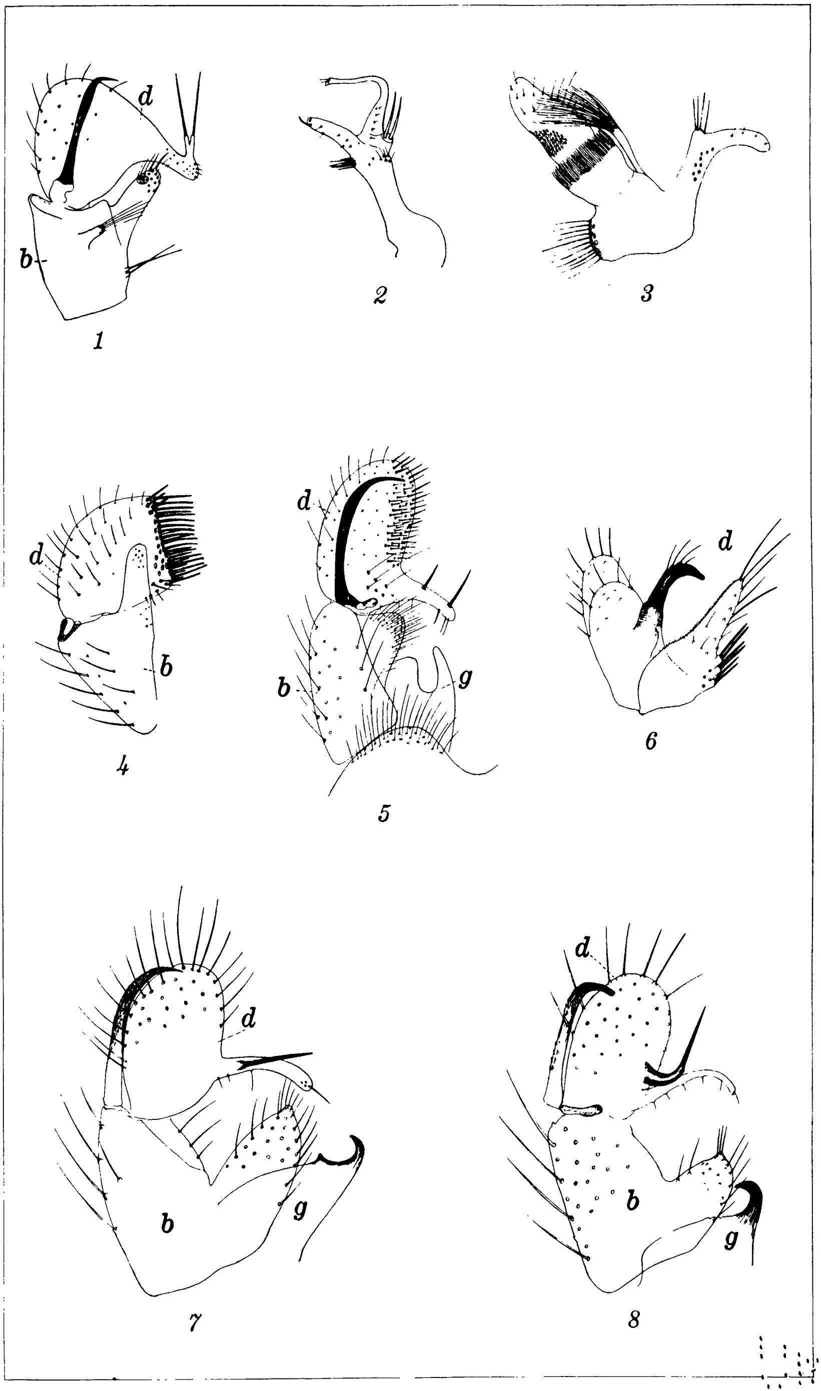

PLATE 1.

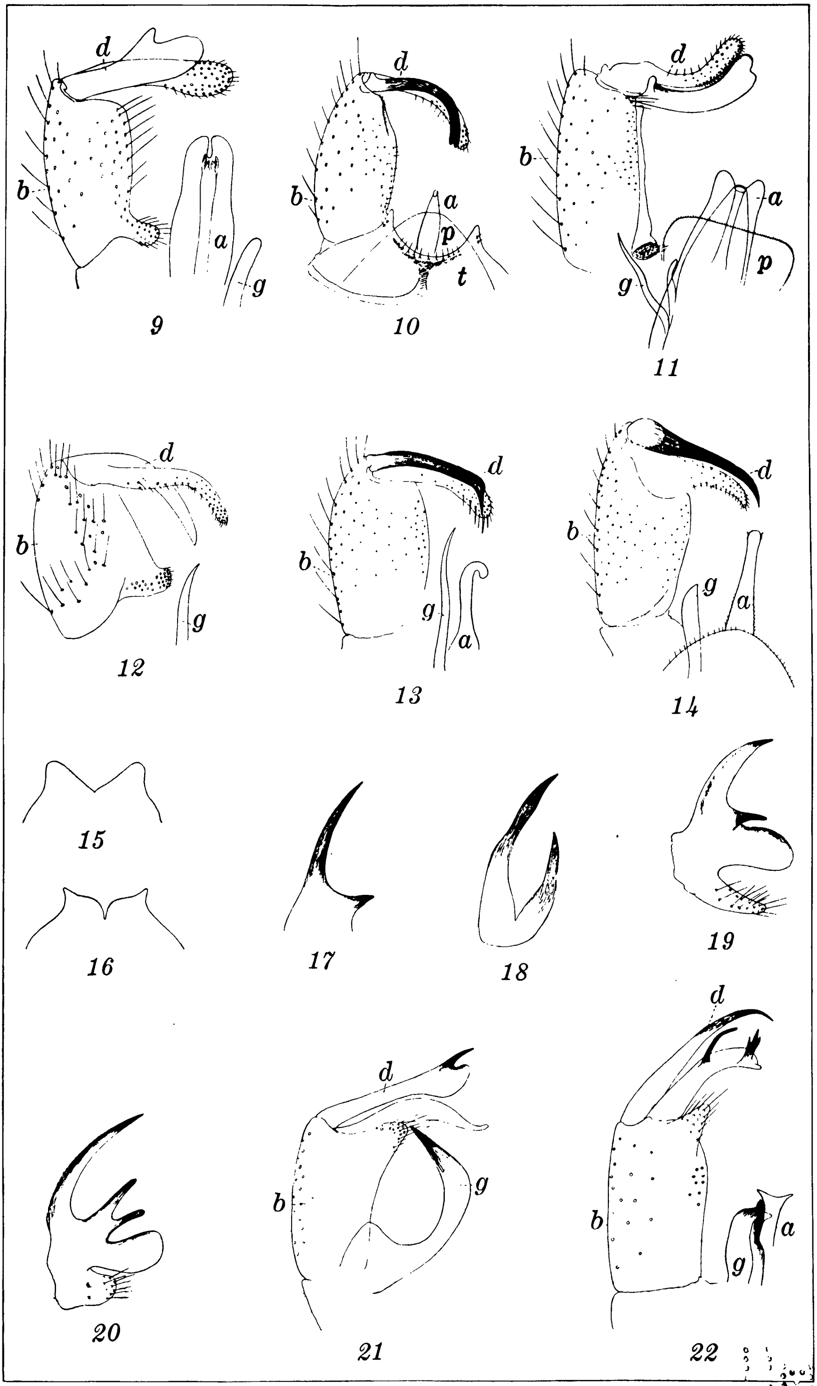
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PLATE 2.

REPORT OF A SACROCOCCYGEAL TERATOMA IN A FILIPINO INFANT

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THREE PLATES

In presenting this case to add to the already profuse literature, I am moved chiefly because of the apparent rarity of these tumors among Filipinos. In a search of the records of nearly ten thousand (9,800) autopsies, covering a period of slightly over fifteen years, from the Philippine General Hospital, the San Lazaro Public Health Service Hospital, and the Manila City Morgue, I have been able to find only one other true teratoma recorded.[1] Numerous monsters have occurred and dermoid cysts of the ovary are apparently not uncommon, but the incidence of solid teratomata is practically negligible. It seems, therefore, of some importance to put this case on record. If this report will act as a stimulus to the collection by other investigators of evidence about this poorly understood group of tumors it will have served its purpose.

In a paper recently published[2] I have collected the reported cases of mediastinal teratomata found in children, presenting at the same time a case occurring in a girl of 4½ years. This group is very much less numerous than the cranial and sacrococcygeal groups, and is perhaps less easy to understand, on the basis of monogerminal tissue implantation. No comparable mediastinal tumors have been noted in the Philippines. In reviewing the literature of the subject, only one hundred nine cases of such mediastinal tumors could be found, the diagnosis of many of which was open to doubt due to lack of histological examination. On the other hand, the literature abounds in case reports and monographs on the teratomata of genital origin, and the sacrococcygeal variety described here is by no means uncommon.

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[1] Gilman, P. K., Axillary teratoma, Philip. Journ. Sci. § B 8 (1913) 231.

[2] Smith, L. W., Mediastinal tumors in children, Surg. Gyn. & Obst. (1923).

It is, therefore, of considerable interest to the embryologist and anatomist, as well as the pathologist, to note the marked apparent difference in incidence of these developmental abnormalities among the Filipinos as a race. Perhaps future study will reveal whether this difference is actual or is simply the result of incomplete statistical evidence. Perhaps it may suggest a similar search in other of the less completely medically investigated countries (China, India, and Africa, for example), where this particular branch of scientific work has been neglected because of the more dramatic field of tropical disease.

I am indebted to Dr. N. M. Saleeby, director of St. Luke's Hospital, Manila, on whose service the case occurred, for the clinical notes and the privilege of publishing these observations.

CLINICAL HISTORY

Baby J., female, born November 1, 1922, at 4.45 a. m., without operative interference. She was considered full-term, and seemed normal at birth in all respects except for the presence of a large sacrococcygeal tumor (Plate 1, fig. 1). She is the second child of normal, healthy Filipino parents. The other child is living and well. There is nothing of interest or importance, otherwise, in the family history.

The baby nursed normally and passed characteristic meconium stools, which began to show evidence of normal digestion in the course of seventy-two hours. She seemed fairly strong and the advisability of operative excision of the tumor was considered. A roentgenological examination of the large bowel was made by means of a bismuth enema on November 3 (Plate 2). During the next day, beginning gangrene of a portion of the tumor was noted, and operation was decided upon as indicated, as the only possible means of saving the baby's life. During the day, however, cyanosis developed, with coldness of the extremities, and "stiffness" of the muscles. Her condition gradually became worse until, finally, ninety-two hours after birth, the baby died.

Complete autopsy was refused, but permission was given to excise the tumor for examination. The report is herewith appended.

PATHOLOGICAL REPORT

Gross.—The specimen consists of an irregularly lobulated tumor mass attached, by a broad skin peduncle and what appears to be a prolongation of the coccygeal cartilage, to the sacral region (Plate 1, fig. 2). The margins are well defined and show no relationship externally to the anus or to the genitalia and, as seen by the X-ray picture, the rectal canal is apparently not involved. A large portion of the tumor is dark reddish, and suggests circulatory disturbances with beginning gangrene. In this dark-colored portion the epithelium is desquamated in many places, exposing a seminecrotic underlying tissue, which for the most part is unrecognizable. Other lobules still retain a healthy appearance with a somewhat thickened skin, in some places smooth, in others wrinkled. These lobules, as will be noted by reference to the plate, vary greatly in size. Certain of them seem fluctuant and suggest a cystic development; others have a resiliency which gives the impression of a loose reticulum of connective or elastic tissue fibers, not unlike the protective pads of cat's claws; still others are firm and unyielding, of a bony or cartilagenous character. The whole tumor is covered by a delicate "downy" growth of short hair, only a millimeter or two in length. In several places, however, particularly in the deeper folds between lobules, small patches of black hair several centimeters in length are found. The whole tumor varies so in gross appearance that further description of the individual lobules would be of little value.

On sectioning the tumor, the confirmatory evidence of its complex or teratoid character is apparent. It is composed of a great variety of tissues, many of which are recognizable to the naked eye. Perhaps most prominent is the bony and cartilagenous development which gives a rough framework or stroma for the other structures. This is most massive centrally. It bears no resemblance to any normal fœtal bones. In the interstices there are numerous cysts, lined in some instances by a smooth, shiny epithelium, in others by a shaggy, soft, friable hæmorrhagic tissue not unlike mucous polypi. Again, islands of nervous tissue are seen, bearing no apparent relationship to the other tissues; some of the latter areas are also cystic in character, suggesting the ventricles of the brain, and are lined by a thin, smooth tissue. Large masses of unrelated striated muscle are definitely recognizable grossly, but apparently are without function. Then, fatty tissue embedded in the meshes of a loose grayish trabeculated stroma, reminiscent of areolar connective tissue, is also prominent. No definite abortive attempts to form fœtal organs are found, and the whole gross appearance is that of a variety of tissues, struggling madly to outgrow one another, the whole maintained in a semblance of order by a covering of skin, which even in places has become overpowered by the purposeless proliferation of the other tissues, with resultant necrosis.

Microscopic.—Sections taken from different portions of the tumor show very marked differences. From one lobule there is a normal skin of the thin type, almost without papillary downgrowths of the epithelium, such as is found on the anterior surface of the forearm. In this, however, the sebaceous and coil glands are relatively excessive in number. The corium too is dense, compared with a similar section of normal skin, and under the corium is a pad of loose areolar collagen fibers supporting a few fibroblasts and large amounts of fatty tissue, the whole being a strange contradiction of structure and function.

In another lobule are other sections of skin, in which the papillary downgrowth of the epithelium is much more prominent. Here, however, immediately under the dense corium there is a layer of neuroglia tissue with a cystic central area lined by a single layer of cuboidal epithelial cells, which on one side of the cyst develop into an atypical choroid plexus (Plate 3), drawing a profuse capillary blood supply from the neighboring wall. Another section from this lobule shows an island of characteristic ganglion cells, with the formation of definite nonmedullated nerve fibers.

The central area of the tumor on section consists histologically of a stroma of bone, cartilage, and connective tissue. There is adult bone with an abortive haversian system, a marrow containing all types of blood cells, and evidence of osteoblast and osteoclast activity. In juxtaposition to one of these islands of bone there is a nodule of stratified epithelium resembling bladder epithelium, forming small cysts filled with desquamated cells. Also, in close approximation to the bone, there is an utterly unrelated mass of striated muscle, some of the cells arranged in characteristic bundles, others occurring singly in the midst of loose areolar tissue. The cartilagenous portion of the stroma is composed chiefly of small branching trabeculæ, some cut in cross section appearing as round islands with no obvious connection.

In another portion of the tumor there is a mass of irregularly arranged smooth muscle, surmounted by a submucosa containing small lymphoid follicles, capillaries, ganglion cells, and abortive adenomatous structures; some occluded and cystic in appearance, filled with a mucoid secretion, others opening into a larger cystic area, presumably representing the lumen of a bit of gut.

Here, as in the gross description, a more complete cataloguing of other sections is merely a reduplication. Enough has been said to show that the tumor is a true teratoma, a parasite, developing as a monogerminal tissue implantation; a misplacement or separation of tissues within a single individual—the so-called autochthonous teratoma, and not a bigerminal implantation or abnormal twin pregnancy.

Diagnosis: Autochthonous teratoma.

ILLUSTRATIONS

PLATE 1

FIG. 1. Tumor in situ.
2. Tumor removed.

PLATE 2

Radiograph, showing tumor mass and large bowel.

PLATE 3

Abortive choroid plexus. Photomicrograph, low power.

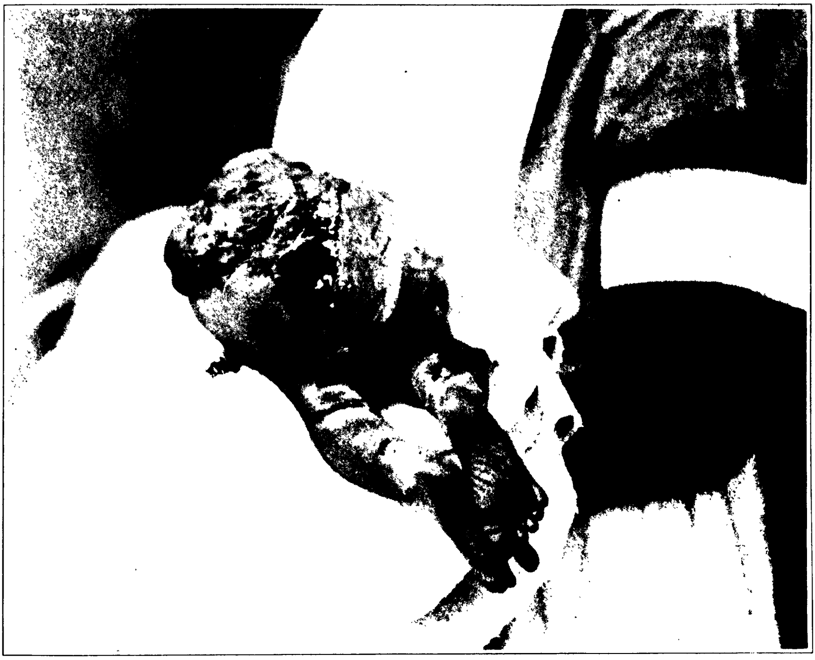

Fig. 1. Tumor in situ.

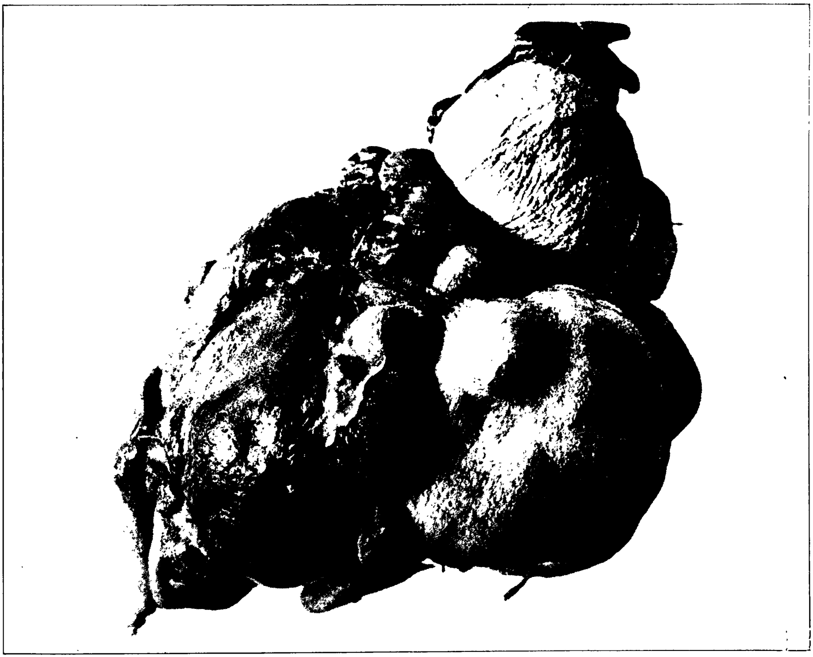

Fig. 2. Tumor removed.

PLATE 1. SACROCOCCYGEAL TERATOMA.

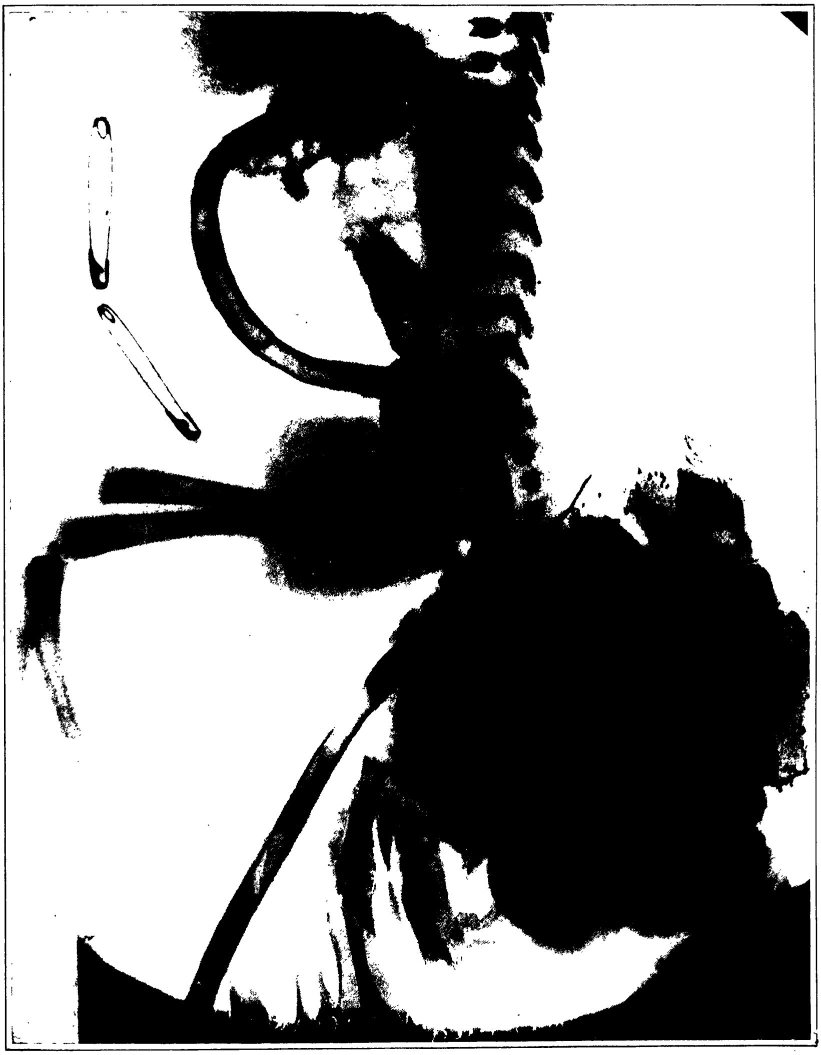

PLATE 2. RADIOGRAPH, SHOWING TUMOR MASS AND LARGE BOWEL.

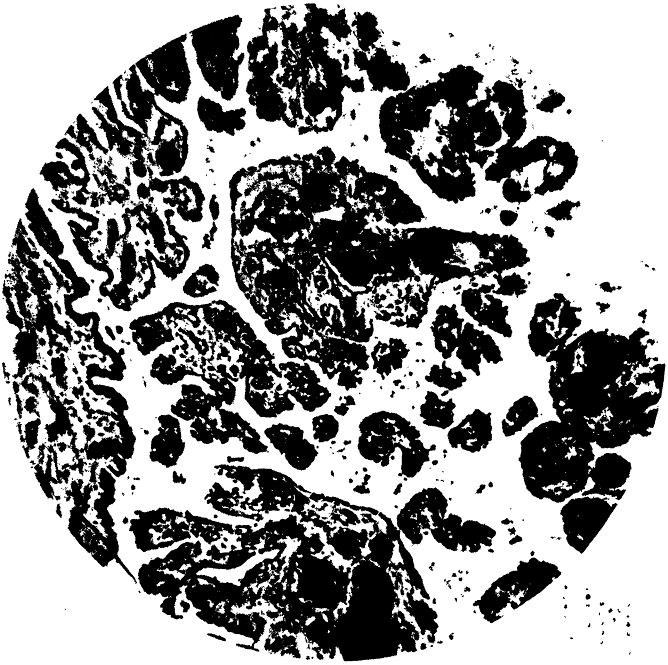

PLATE 3. ABORTIVE CHOROID PLEXUS. PHOTOMICROGRAPH, LOW POWER.

CHAULMOOGRA ETHYL, PROPYL, BUTYL, AND AMYL ESTERS [1]

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ONE PLATE AND TWO TEXT FIGURES

Chaulmoogra ethyl esters (more correctly the mixed ethyl esters of the fatty acids which occur and whose glycerides occur in chaulmoogra oil) have been made and used for some time at Culion Leper Colony. During that time a few simple studies have been made resulting in improvements on the process [2] originally used and these studies have been extended at the suggestion of Dr. H. W. Wade, chief pathologist, to include the preparation of other esters, the therapeutic value of which is now being tested by the clinical staff. It is the purpose of the present paper to record the results obtained from these chemical studies, in so far as they may be of general interest, and the methods of preparation used by us at the present time.

EXPERIMENTAL PREPARATION OF CHAULMOOGRA ETHYL ESTERS

The method of preparation which requires the preliminary liberation of the fatty acids has never been used by us on a large scale, on account of the greater economy of the direct process. Recent improvements in the preparation reaction itself have been in the direction of cutting down the amount of alcohol used. Although we have distilled the washings to recover the excess alcohol we have always lost considerable amounts, partly by mechanical loss, in the neutralization and repeated fractionations involved, and partly by formation of ether during the reaction with chaulmoogra oil. We have not been able to recover this ether economically due to the comparatively high temperature of our cooling water.

Since the reaction between alcohol, chaulmoogra oil, and sulphuric acid, as we have carried it out, is a heterogeneous one, and therefore not only varying in speed according to the amount of stirring, but also necessitating a higher temperature or much more time or catalyst than a homogeneous reaction, experiments were made as to the intersolubility of the liquids involved. The solubility of chaulmoogra oil in an excess of alcohol is too slight to consider carrying out the reaction in this kind of solution. On the other hand, alcohol, if dehydrated, is quite soluble in an excess of chaulmoogra oil. At room temperature (30° C.) chaulmoogra oil dissolves about 68 per cent of its volume of 99 per cent alcohol. This solution, or even one containing less alcohol, is quite unstable toward the addition of somewhat polar substances. For example, a solution of 10 mils alcohol in 30 mils chaulmoogra oil is clouded immediately by the addition of a few bubbles of dry hydrochloric acid gas, by the addition of 0.04 mil sulphuric acid, or by the addition of a few drops of glycerol or 90 per cent alcohol. As an acid catalyst is necessary, glycerol is a product of the desired reaction, and water is difficult to remove from 95 per cent alcohol, it was decided that a homogeneous reaction mixture is practically unobtainable. Nevertheless, for the purpose of studying the reaction, especially in comparison with other alcohols which mix readily with oils, two reaction mixtures were prepared which were homogeneous at the outset. These were made with 99 per cent alcohol. In one case (Table 2, mixture C) very little sulphuric acid was used, and in the other (Table 2, mixture A) ether was added to act as solvent. These mixtures, like all the rest mentioned in this paper, did not remain homogeneous, but soon gave a separate layer containing glycerol, alcohol, and sulphuric acid. This separation was not entirely detrimental to the reaction, as it removed some of the glycerol from the main reacting layer. A third mixture (Table 2, mixture B) was made up, with the use of dry hydrochloric acid gas as a catalyst. This had two layers from the start, no ether being added.

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[1] Submitted for publication August 12, 1923, with the permission of the Director of Health and approval of the Philippine Leprosy Research Board.

[2] Perkins, G. A., Philip. Journ. Sci. 21 (1922) 1.

Table 1 shows the characteristics of the chaulmoogra oil used in the above-mentioned mixtures. Table 2 gives the results of the experiment.

TABLE 1.—*Characteristics of the chaulmoogra oil used for experimental preparation of ethyl, propyl, butyl, and amyl esters.*

Refractive index, *n*/30/D	1.4757
Acidity (as oleic), per cent	18.2
Specific gravity, 30/30	0.9497
Optical rotation 10 centimeters/30/D, degrees	44.5

Amounts of reagents.—The composition of the three mixtures is shown in Table 2. Two hundred seventy-six grams of chaulmoogra oil were taken for mixtures A and B. This was the amount found to be equivalent to one mol of alkali (in the process of saponification). Two mols of alcohol were used, and this quantity is shown by the results of the experiment to be sufficient for thorough conversion to ethyl ester. Mixture C was measured in round numbers of mils, with about 2.5 molecular equivalents of alcohol.

Three-hundredths of a mol of acid was used in A and B, this being the quantity of sulphuric acid that could be added to the normal propyl alcohol mixture (see Table 5) without causing separation into two layers. One-tenth mil of sulphuric acid was chosen for mixture C, being practically the maximum that could be added to this mixture without causing separation into two layers.

Study of the reaction.—The three mixtures were placed in stoppered bottles of 8 centimeters inner diameter, and allowed to stand at room temperature (averaging 30° C. with a daily variation of about 4° C.). The mixtures were stirred only before taking samples. After about two months the reaction was finished by boiling gently. The mixture catalyzed by hydrochloric acid became dark red on standing, and all became darker on boiling. Mixtures A and B retained a small glycerol layer on boiling, but mixture C became homogeneous again on boiling.

The course of the reaction was traced rather easily with a refractometer. Samples of about 5 mils were taken at the intervals shown in Table 2. Each sample was washed with 20 mils of water to remove mineral acid and steamed to remove alcohol. The refractive index was then taken at room temperature and corrected to 30° C. allowing for a drop of 0.0004 per degree temperature rise, as determined by experiment. The sample thus tested was essentially a mixture of unchanged oil and newly formed chaulmoogra ethyl esters, and the refractive index varied considerably according to the relative amounts of these two constituents. The distilled and purified ester from mixture A had a refractive index of 1.4563 (see Table 1) and that from mixture B, 1.4566. The product from mixture C was excluded on account of high acidity, so the average of 1.45645 was taken as the refractive index of the ethyl esters from the sample of chaulmoogra oil in hand. The total decrease in refractive index from oil (1.4757) to ethyl ester (1.45645) was therefore 0.01925. Assuming the decrease of refractice index to be proportional to the amount of ethyl ester in the various samples tested, this decrease (from 1.4757) in each case was divided by 0.0001925 to find the percentage of ethyl ester. The proportionality above assumed is evidently close to the actual fact, as a mixture of 5 grams ethyl ester of refractive index 1.4563 with 5 grams of chaulmoogra oil of index 1.4757 was found to have an index of 1.4660, exactly the average. The calculated percentages of ethyl ester in the samples freed, as above described, from alcohol and solvent are given in Table 2 and shown as graphs in fig. 1. Due to the presence of free fatty acids, mono- and di-glycerides, and other constituents of unknown effects, the calculated percentages cannot be considered accurate, but they certainly have a comparative value.

Effect of added ether.—To ascertain whether ether has any esterifying effect of its own, a mixture (fig. 1, mixture D) of 2 mols dry ether, 0.03 mol sulphuric acid, and 1 equivalent (276 grams) of chaulmoogra oil was studied. This mixture reacted very slowly (see fig. 1), the refractive index at sixty-six days being 1.472, which corresponds to about 19 per cent eythl ester.

The direct chemical effect of the ether in mixture A was, judging from mixture D, not enough to balance the slowing down of the reaction by its diluting effect. Nevertheless, mixture A reacted more rapidly than B (see fig. 1), as was to be expected from the fact that the ether increased the intersolubility of the alcohol and chaulmoogra oil.

During the boiling of mixture A the ether was driven off so that it was not a factor in the final result.

The effect of the catalyst.—The greater rapidity in the early stages of the reaction in mixture A cannot be ascribed to the sulphuric acid used, because this acid was found to be practically equivalent to hydrochloric in the first part of the reaction with propyl and butyl alcohols (see Tables 5 and 7) when no ether was used. The higher final value of ester in mixture A, however, indicates that sulphuric acid produces a distribution of alcohol and glycerol in the two layers which is more favorable to the production of ethyl ester than the distribution occurring in the presence of hydrochloric acid.

Mixture C (see fig. 1) had evidently too little catalyst for practical purposes, either for a reaction in the cold or for boiling.

Isolation of ethyl ester from the crude reaction mixture.—When the reaction had practically ceased, as shown by the refractive index tests, mixtures A, B, and C were washed with water to remove alcohol and sulphuric acid. (Mixture D was discarded.) The acidity at this stage was comparatively low, as is shown in Table 2. Nevertheless, difficulty was encountered in the next stage, that of removing the free fatty acid. The reason for removing this was that early in our work on chaulmoogra ethyl esters we found difficulty in distillation, which we ascribed to the free fatty acid. Since then we have, until recently, washed with alkali before distilling.

The method used in washing mixtures A and B was the one that has been found fairly successful in our routine practice; namely, to mix with about two volumes of cold water, make slightly alkaline, and put on a warm plate or steam bath until the emulsion separates. Three faults were found in this method; first, that a slightly alkaline solution may be in equilibrium with ester containing appreciable free fatty acid; second, that the emulsions required a long time to separate, especially if more than very slightly alkaline; and third, that the emulsions often hydrolyzed on long heating so as to become more acid than they were originally. The simple expedients of using hot instead of cold water and of adding sufficient excess of alkali were found to obviate these difficulties, but the data on mixtures A and B are examples of the result of starting the emulsion cold. No acidity data were taken, but the refractive index (Table 2) shows the presence of free fatty acid in each case. Mixture C was treated with benzene to extract the ester, and alcohol was added to break the emulsion. The benzene was later removed by distillation with steam. The loss of ester was high and the refractive index was not reduced.

The washed products were distilled in a vacuum of about 10 millimeters pressure. A 500-mil Pyrex "creosote" distilling flask was used, and two small pieces of copper gauze were inserted in the neck to prevent splashing over. A pebble was added to minimize bumping.

The proportion of residue to distillate (Table 2) was found to correspond as closely as would be expected to the calculated percentages of unchanged oil and ethyl ester.

The yields of final product were very low, especially from mixture C, but this is obviously due to the repeated sampling and the experimentation on separation of emulsions. Yield data are given in the following section.

TABLE 2.—*Experimental preparation of chaulmoogra ethyl esters.*

	Mixture A.	Mixture B.	Mixture C.
Composition of mixture:			
Chaulmoogra oil	276 grams (equivalent to 1 mol).	276 grams (equivalent to 1 mol).	100 mils.
Ethyl alcohol, 99 per cent.	93 grams (2 mols)	93 grams (2 mols)	50 ml. (2.5 mol equivalent).
Sulphuric acid, 95 per cent.	3.1 grams (0.03 mol)	None	0.1 ml. (0.005 mol equivalent).
Hydrochloric acid, dry.	None	1.1 grams (0.03 mol)	None.
Ethyl ether, dry	148 grams (2 mols)	None	None.
Refractive index, $n/30/D$, and calculated per cent ethyl ester after standing—			
1 hour	1.4752, 3 per cent		
2 hours	1.4749, 4 per cent		
5 hours	1.4739, 9 per cent		
10 hours	1.4730, 14 per cent		
1 day	1.4713, 23 per cent	1.4733, 12 per cent	1.4737, 10 per cent.
2 days	1.4691, 34 per cent	1.4724, 17 per cent	1.4732, 13 per cent.
3 days	1.4682, 39 per cent	1.4710, 24 per cent	1.4730, 14 per cent.
4 days	1.4668, 46 per cent	1.4701, 29 per cent	
6 days	1.4641, 60 per cent		
7 days			1.4731, 14 per cent.
8 days		1.4680, 40 per cent	
10 days	1.4619, 72 per cent		
14 days	1.4614, 74 per cent		
59 days			1.4699, 30 per cent.
60 days		1.4594, 85 per cent	
66 days	1.4585, 90 per cent		
Refractive index, $n/30/D$, and calculated per cent ethyl ester after boiling—			
3 hours	1.4581, 92 per cent		
10 hours			1.4641, 60 per cent.
12 hours		1.4588, 88 per cent	
24 hours		1.4588, 88 per cent	1.4618, 72 per cent.
28 hours	1.4573, 96 per cent		
48 hours			1.4611, 76 per cent.
72 hours			1.4607, 78 per cent.
Product washed with water:			
Acidity (as per cent oleic).	3.4	3.1	3.3
Product washed with alkali:			
Weight	166 grams	188 grams	28 grams.
Refractive index, $n/30/D$.	1.4580	1.4587	1.4607
Product distilled:			
Weight	151 grams	146 grams	23 grams.
Acidity (as per cent oleic).	4.0	1.8	4.1.

TABLE 2.—*Experimental preparation of chaulmoogra ethyl esters.*—Cont.

	Mixture A.	Mixture B.	Mixture C.
Residue in still, weight	6 grams	17 grams	2 grams.
Distillate washed with alkali:			
Weight	107 grams	129 grams	6 grams.
Refractive index, $n/30/D$.	1.4563	1.4566	(1.4574).
Acidity (as per cent oleic).	0.55	0.55	4.1
Specific gravity, 30/30.	0.902	0.902	
Optical rotation, 10 centimeters/30/D.	35.9°	35.9°	28.1°

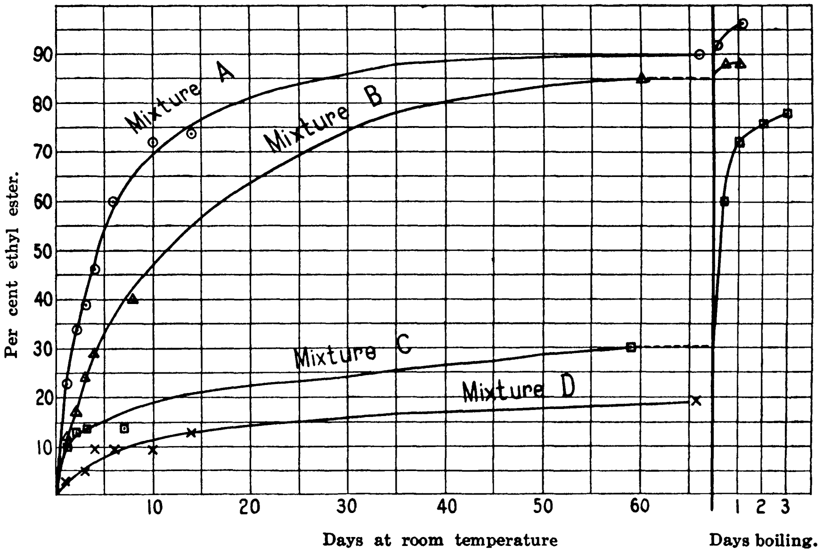

FIG. 1. Experimental preparation of chaulmoogra ethyl esters.

PRESENT METHOD OF MANUFACTURE OF CHAULMOOGRA ETHYL ESTERS

In our routine preparation of chaulmoogra ethyl esters at Culion Leper Colony we originally used a large excess of alcohol to insure complete reaction, but have gradually been economizing on the alcohol consumption. The proportions used by us at present are 10 liters chaulmoogra oil, 5 liters alcohol (95.5 per cent by volume), and 100 mils sulphuric acid. This mixture has been found by Mr. A. O. Cruz, who is in charge of this process, to give good results if the boiling is vigorous and is continued for about forty-eight hours. The principal advantage of vigorous boiling is undoubtedly that it keeps the two layers well mixed. Samples taken after twenty-four hours vigorous boiling show, after washing, a refractive index of about 1.4590, while the forty-eight-hour samples have an index of about 1.4575. The boiling is done in stoneware acid carboys of 26-liter capacity set in concrete tubs which serve as steam jackets. The alcohol vapor is condensed and returned to the boiling mixture by condensers of 13-millimeter brass pipe 1.5 meters long with water jackets of 38-millimeter galvanized iron pipe soldered on (Plate 1, fig. 1).

Typical data on the reaction are shown in Table 3.

TABLE 3.—*Routine preparation of chaulmoogra ethyl esters, reaction data.*

Run No.	Twenty-four hour sample.		Forty-eight hour sample.	
	Refractive index.	Acidity.	Refractive index.	Acidity.
		Per cent.		*Per cent.*
125	1.4591	3.7	1.4576	3.7
126	1.4584	3.9	1.4573	3.7
127	1.4595	3.9	1.4583	3.7
128	1.4591	4.6	1.4575	3.7

The contents of the carboy are washed three times with about 20 liters of water, and then dried in a steam kettle. The yield from 10 liters of oil is about 11 liters. The first washing is neutralized with lime and fractionally distilled to recover the alcohol which it contains.

Distillation (Plate 1, fig. 2).—The chaulmoogra ethyl esters are distilled at about 30 millimeters pressure in essentially the same apparatus that was previously used at the Bureau of Science.[3] We have recently had the top and bottom of the body of the still welded on, as troublesome leaks developed in the screwed joints in spite of the use of cement. The joint between the still head and the reducing coupling which forms the top of the body gives no trouble if covered with good fire-proof cement, but we find extra-heavy pipe advisable for the still head as frequent use of the wrench upon it is necessary. The air condenser is of 13-millimeter pipe, with vacuum connection at a tee. Breakage of the receiver was obviated by replacing the separatory funnel with a 500-mil leveling bulb, the outlet of which is attached by cement and pipe fittings to a brass stopcock.

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[3] Perkins, G. A., Philip. Journ. Sci. 21 (1922) 8. The body is of 15-centimeter iron pipe, 30 centimeters long, and still head 5 by 150 centimeters.

The electric heater for the body of the still has been replaced by a New Perfection single-burner stove, the chimney of which is fitted almost airtight to a length of 250-centimeter stovepipe. This stovepipe, surrounded and extended upward by insulation of asbestos pipe covering, forms a hot air bath for the still and still head. A wrapping of 25 turns of No. 22 Chromel A wire around the still head is used for auxiliary electric heating (110 volts).

Attempts have been made to remove the residue through a hole near the bottom of the still, but a portion of the residue usually becomes carbonized and spongy, so that it is necessary to take the still apart for cleaning. No solvent has been found for this spongy mass, though boiling solvent naphtha or kerosene softens it. Usually we unscrew the still head after distilling about 50 liters, heat the body, and pour out any liquid contents. Upon further heating the spongy contents become brittle and are then scraped out.

Washing with alkali.—Free fatty acid has been found to be irritating, so we aim to reduce this to a minimum in all drugs which are to be injected. This may be done by washing with alkali either before or after distilling. Removal of fatty acid before distillation seems to make distillation somewhat smoother, and practically no rise in acidity occurs during well-regulated distillation, so this is the method which we used for some time. At present, however, we are washing after distillation, because this was sometimes found advisable even if the ester was washed before distillation, because the distilled ester has less tendency to emulsify, and because the alkali is useful in removing impurities, such as traces of aldehydes, which are formed during distillation. Typical results from washing before and after distillation are shown in Table 4. It may be seen that the yield of purified ester from 10 liters of chaulmoogra oil is, by our present method, exemplified by run No. 133, about 9 liters.

TABLE 4.—*Chaulmoogra ethyl esters washed with alkali before and after distillation.*

	Run No.	
	132	133
Crude ester:		
Volume liters	11	11
Refractive index $n/30/D$	1.4580	1.4574
Acidity (as per cent oleic)	4.4	4.3
Ester washed with alkali:		
Volume liters	7.0	
Acidity (as per cent oleic)	0.5	
Ester distilled:		
Volume liters	6.3	9.4
Acidity (as per cent oleic)	1.8	3.0
Distillate washed with alkali:		
Volume liters	----------	9.0
Acidity (as per cent oleic)	----------	0.2

About 10 liters of distilled ester are placed in a 26-liter stoneware carboy, and steam is passed through for two hours, or until the sharp odor produced by heating has disappeared. The contents of the carboy are transferred to a copper kettle in which 40 grams of sodium hydroxide have been dissolved in sufficient boiling water to make, with the water contained in the carboy, 20 liters. The mixture is stirred without further heating and allowed to settle for half an hour. The lower layer is drawn off and put in a barrel for recovery of fatty acid. The upper layer is washed twice with its own volume of boiling water. When all the deposited water has been removed the ester is filtered and sterilized by heating to 150° C. in small bottles. The acidity (about 0.2 per cent) and optical rotation (about 40.5°) of each lot are recorded. The refractive index, $n/30/D$, is about 1.4559, and the specific gravity, 30/30, about 0.901.

Since the addition of a small amount of iodine has been found by the medical staff to reduce the irritating effects of chaulmoogra ethyl esters, most of this drug is mixed with 0.5 per cent iodine before use. It has further been found that iodine increases rather than decreases the irritating effects unless the mixture is heated for some time. The change on heating may be observed as a change in color from green to reddish brown. We take care always to produce the brown color. Another important point is thorough drying of the ester before the addition of iodine, since we find that the latter effects by catalysis the hydrolysis of several per cent of the ester if water is present.

A mixture of the iodized esters with 10 per cent of creosote (U. S. P.) has been reported upon very favorably by the medical staff and tentatively adopted on an extensive scale. We cannot state at present whether any detrimental reaction between the creosote and iodine is likely to occur, but use the following method of preparation to avoid any such reaction:

Nine liters of purified chaulmoogra ethyl esters are heated to 150° C. to drive off suspended and dissolved water. Forty-five grams of iodine are stirred in, and the mixture is cooled and filtered. The mixture is then heated to 160° C. for two hours, or until brown, 1 liter of perfectly clear, anhydrous, U. S. P. creosote is added, and the whole transferred to sterile bottles without further heating.

EXPERIMENTAL PREPARATION OF CHAULMOOGRA PROPYL ESTERS

The propyl alcohols are more soluble in chaulmoogra oil than is ethyl alcohol, and therefore form a homogeneous reaction mixture more readily with it. Experiments using these alcohols were run in parallel with those described above using ethyl alcohol. The proportion used and results obtained are shown in Table 5. The alcohols gave no evidence of water when tested with anhydrous copper sulphate. The chaulmoogra oil used was the same as that described in Table 1.

All three mixtures were homogeneous at the start, but after a few days a lower glycerol layer appeared in each which persisted even in the final boiling.

Primary (*normal*) propyl alcohol reacted rapidly and completely in the presence of sulphuric acid (see fig. 2, A_p). Due to errors mentioned above in connection with the ethyl esters the figures indicate slightly more than 100 per cent of ester. Hydrochloric acid (fig. 2, B_p) was equally effective as a catalyst in the early stages of the reaction, but did not carry it to completion. Evidently the glycerol did not separate out so completely in this case. Secondary (*iso-*) propyl alcohol (fig. 2, A_s) reacted more slowly, as would be expected from the general behavior of secondary alcohols.

The final boiling caused very little change, although the temperature, about 100° C., was sufficient to accelerate the reaction considerably. The final result was accordingly accepted as close to equilibrium.

Recovery of alcohol.—The excess alcohol was removed by washing with water, and the wash waters were distilled through a fractionating column. The distillate coming over at 80 to 95° C. was treated with calcium chloride and the lower layer which formed removed. This process was repeated until no more calcium chloride would dissolve, and the upper layer was measured. Such an upper layer contains about 0.7 gram of recoverable alcohol per mil, and we have calculated the figures in Table 5 on this basis. The further treatment, which was carried out after combining the crude alcohol from several experiments, consisted in heating with calcium oxide and distilling. The recovery yields were of course low, due not only to the nature of the process, but also to the repeated sampling of the original mixture.

Purification.—The final treatment of the propyl esters was approximately the same as that described above for the ethyl esters. The same high losses from refractory emulsions are shown in Table 5. The low rotatory power of the product from mixture B_p is probably ascribable to too slow distillation. Continued heating above 200° has been found to lower the rotation, probably by racemization.

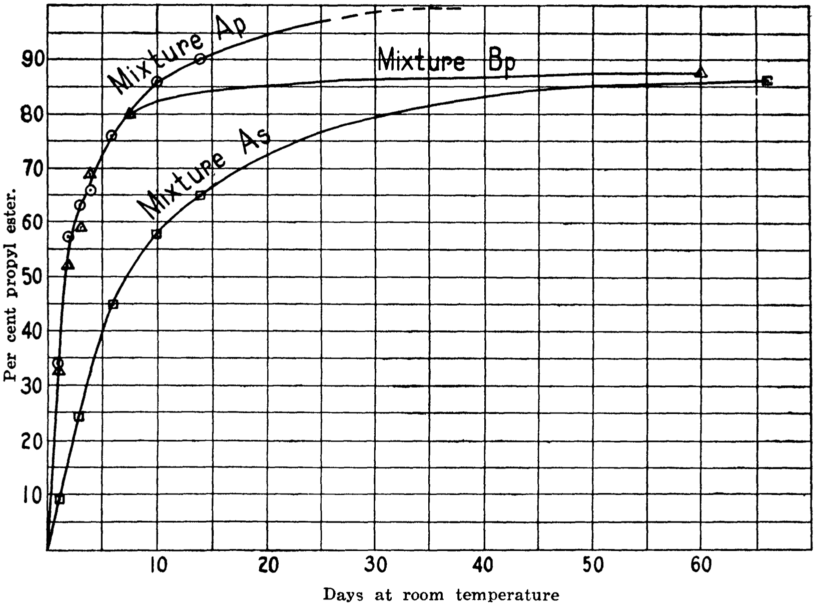

FIG. 2. Experimental preparation of chaulmoogra propyl esters.

TABLE 5.—*Experimental preparation of chaulmoogra propyl esters.*

	Mixture A_p.	Mixture B_p.	Mixture A_s.
Composition of mixture:			
Chaulmoogra oil	276 grams (equivalent to 1 mol).	276 grams (equivalent to 1 mol).	276 grams (equivalent to 1 mol).
Propyl alcohol, primary.	120 grams (2 mols)	120 grams (2 mols)	None.
Propyl alcohol, secondary.	None	None	120 grams (2 mols).
Sulphuric acid, 95 per cent.	3.1 grams (0.03 mol)	None	3.1 grams (0.03 mol).
Hydrochloric acid, dry	None	1.1 grams (0.03 mol)	None.
Ethyl ether, dry	None	None	87 grams (0.5 mol).
Refractive index, *n*/30/D, and calculated per cent propyl ester after standing—			
1 hour	1.4749, 4 per cent		1.4758
2 hours	1.4741, 9 per cent		1.4754, 1 per cent.
5 hours	1.4728, 16 per cent		1.1752, 2 per cent.
10 hours	1.4718, 21 per cent		1.4747, 5 per cent.
1 day	1.4695, 34 per cent	1.4696, 33 per cent	1.4738, 9 per cent.
2 days	1.4652, 57 per cent	1.4661, 52 per cent	
3 days	1.4644, 63 per cent	1.4648, 59 per cent	1.4703, 24 per cent.
4 days	1.4636, 66 per cent	1.4630, 69 per cent	
6 days	1.4617, 76 per cent		1.4658, 45 per cent.
8 days		1.4611, 80 per cent	
10 days	1.4600, 86 per cent		1.4627, 58 per cent.
14 days	1.4592, 90 per cent		1.4613, 65 per cent.
60 days		1.4598, 87 per cent	
66 days	1.4567, 102 per cent		1.4567, 86 per cent.
Refractive index, *n*/30/D, and calculated per cent propyl ester after boiling—			
5 hours		1.4595, 88 per cent	
6 hours	1.4570, 101 per cent		1.4563, 87 per cent.
Alcohol recovered:			
Weight	30 grams	31 grams	35 grams.
Mols	0.50	0.52	0.58
Product washed with water:			
Weight			216 grams.
Acidity (as per cent oleic).	3.2	4.3	8.4
Product washed with alkali:			
Weight	172 grams	145 grams	139 grams.
Refractive index, *n*/30/D.	1.4582		1.4556
Fatty acid recovered:			
Weight	26 grams	76 grams	74 grams.
Product distilled:			
Weight	140 grams	102 grams	120 grams.
Acidity (as per cent oleic).	5.2	3.4	3.2

TABLE 5.—*Experimental preparation of chaulmoogra propyl esters*—Cont.

	Mixture A_p.	Mixture B_p.	Mixture A_s.
Residue in still, weight	23 grams	30 grams	10 grams.
Distillate washed with alkali:			
Weight	126 grams	50 grams	108 grams.
Refractive index, n/30/D.	1.4574	1.4573	1.4535
Acidity (as per cent oleic).	0.33	0.35	0.22
Specific gravity 30/30.	0.901	0.904	0.894
Optical rotation, 10 centimeters /30/D.	33.1°	30.7°	37.8°

PRESENT METHOD OF PREPARATION OF CHAULMOOGRA PROPYL ESTERS

We have made only a few runs with primary propyl alcohol, the one shown in Table 6 being the latest. These esters are being used experimentally in small quantities by the medical staff.

TABLE 6.—*Routine preparation of chaulmoogra propyl esters, run 3.*

Chaulmoogra oil, ml	600
N-propyl alcohol, ml. (2 equivalents)	300
Sulphuric acid, ml	1
Temperature (boiling), °C	91–103
Time, hours	5
Refractive index *n*/30/D	1.4586
Product washed with alkali, ml	480
Fatty acid recovered, grams	155
Alcohol recovered, ml. (0.73 equivalent)	110
Product distilled:	
Volume, ml	380
Acidity (as oleic), per cent	2.3
Residue in still, grams	41
Distillate washed with alkali:	
Volume, ml	320
Acidity, per cent	0.50
Optical rotation, 10 centimeters/30/D, degrees	38.3

EXPERIMENTAL PREPARATION OF CHAULMOOGRA BUTYL AND AMYL ESTERS

Experiments using *n*-butyl and *iso*-amyl (amyl, pure, Merck, principally *iso*-amyl) alcohols were made in parallel with those using ethyl and propyl alcohols. The data are given in

Table 7. These alcohols are less readily thrown out of solution in chaulmoogra oil than are the propyl alcohols, but the glycerol formed in the reaction soon produced a separate liquid layer as in the former cases. The same lot of chaulmoogra oil was used as before (see Table 1). The alcohols showed no water when tested with copper sulphate.

The graphs for butyl and amyl alcohol are not shown, as those for mixtures A_b and A_a (Table 7) are almost identical with A_p in fig. 2 and that for B_b (Table 7) is very close to B_p in fig. 2.

The purification of the butyl and amyl products differed somewhat from that of the propyl esters. The reaction mixture was washed with water to remove mineral acid, after which both layers were distilled separately with steam to remove the excess butyl or amyl alcohol. The lower layer of the combined distillate was again steam distilled, and the process was repeated once or twice more, each distillation being continued until the condensate was practically odorless. It was found advisable to collect each distillate in two portions, the cut being made when the liquid dropping from the condenser no longer had two layers. After three or four distillations the lower layer of the distillate was so small that it could be discarded, and all the combined upper layers from the distillates were treated with calcium chloride. The lower layer was pipetted off and calcium chloride added. After standing a few hours the alcohol was poured off and redistilled.

The ester from which excess alcohol had been removed was distilled without previous washing with alkali in the cases of mixtures B_b and A_a. Otherwise the procedure was similar to that described for the propyl esters.

TABLE 7.—*Experimental preparation of chaulmoogra butyl and amyl esters.*

	Mixture A_b.	Mixture B_b.	Mixture A_a.
Composition of mixture:			
Chaulmoogra oil	276 grams (equivalent to 1 mol).	276 grams (equivalent to 1 mol).	276 grams (equivalent to 1 mol).
Butyl alcohol, *normal*	148 grams (2 mols)	148 grams (2 mols)	None.
Amyl alcohol, *iso*	None	None	176 grams (2 mols).
Sulphuric acid, 95 per cent.	3.1 grams (0.03 mol).	None	3.1 grams (0.03 mol).
Hydrochloric acid, dry.	None	1.1 grams (0.03 mol)	None.

TABLE 7.—*Experimental preparation of chaulmoogra butyl and amyl esters*—Continued.

	Mixture A_b.	Mixture B_b.	Mixture A_a.
Refractive index, *n*/30/D and calculated per cent butyl (or amyl) ester after standing—			
1 hour	1.4743, 8 per cent		1.4743, 7 per cent.
2 hours	1.4739, 10 per cent		1.4726, 16 per cent.
5 hours	1.4724, 18 per cent		1.4724, 18 per cent.
10 hours	1.4713, 24 per cent		1.4708, 26 per cent.
1 day	1.4679, 42 per cent	1.4794, 34 per cent	1.4675, 44 per cent.
2 days	1.4647, 59 per cent	1.4664, 49 per cent	1.4646, 59 per cent.
3 days	1.4629, 69 per cent	1.4639, 63 per cent	1.4628, 69 per cent.
4 days	1.4622, 73 per cent	1.4625, 66 per cent	1.4613, 77 per cent.
6 days	1.4601, 84 per cent		1.4596, 80 per cent.
8 days		1.4603, 83 per cent	
10 days	1.4586, 92 per cent		1.4582, 93 per cent.
14 days	1.4585, 93 per cent		1.4581, 94 per cent.
60 days		1.4581, 92 per cent	
66 days	1.4572, 99 per cent		1.4569, 100 per cent.
Refractive index, *n*/30/D and calculated per cent butyl (or amyl) ester after boiling 2 hours.	1.4572, 99 per cent	1.4580, 95 per cent	1.4573, 98 per cent.
Alcohol recovered:			
Weight	50 grams	49 grams	82 grams.
Mols	0.68	0.66	0.93
Product washed with water:			
Weight	243 grams	267 grams	207 grams.
Acidity (as per cent oleic)	2.4	2.3	2.8
Product washed with alkali, weight.	214 grams		
Product distilled:			
Weight	187 grams	250 grams	176 grams.
Acidity (as per cent oleic).	2.6	3.4	2.8
Residue in still, weight	16 grams	11 grams	23 grams.
Distillate washed with alkali:			
Weight	155 grams	189 grams	154 grams.
Refractive index, *n*/30/D.	1.4573	1.4569	1.4569
Acidity (as per cent oleic).	0.33	0.16	0.11
Specific gravity, 30/30	0.901	0.897	0.894
Optical rotation, 10 centimeters/30/D.	33.6°	36.1°	32.9°

PRESENT METHOD OF PREPARATION OF CHAULMOOGRA BUTYL AND AMYL ESTERS

Chaulmoogra *n*-butyl esters have been used experimentally for a short time by the medical staff and appear to be less irritating than the ethyl esters, although it is not yet certain that they can be used to replace the latter. Chaulmoogra *iso*-amyl esters are also being tried. The preparation of the butyl and amyl esters is exemplified in Table 8. The method is very similar to that used for the routine preparation of ethyl esters, but the excess alcohol is removed by steam distillation as described in the preceding section. The simplest way to remove water from the upper layers thus secured is to distill fractionally through a column.

TABLE 8.—*Routine preparation of chaulmoogra n-butyl and iso-amyl esters.*

		Designation of run.	
		Butyl-3.	Amyl-3.
Chaulmoogra oil	ml	2,000	2,000
Alcohol	ml	1,000	1,200
Sulphuric acid	ml	10	12
Heated	hrs	35	48
Temperature	°C	85	85
Refractive index n/30/D		1.4589	1.4593
Product steamed:			
Volume	ml	2,020	2,460
Acidity (as oleic)	per cent	4.4	7.0
Alcohol recovered	ml	375	525
Distillate:			
Volume	ml	1,835	1,900
Acidity (as oleic)	per cent	4.0	7.3
Residue	g	283	265
Distillate washed with alkali	ml	1,555	1,250
Fatty acid recovered	ml	125	561
Sterilized ester:			
Acidity (as oleic)	per cent	1.3	0.67
Optical rotation, 10 centimeters/30/D	degrees	37.5	35.1

SUMMARY

1. Experiments on the preparation of chaulmoogra ethyl, propyl, butyl, and amyl esters are described, in which the course of the reaction between chaulmoogra oil and the alcohol was followed by means of a refractometer.

2. The proportion of 2 mols of the alcohol to one molecular equivalent of chaulmoogra oil was found to be sufficient for a practical conversion of the oil into the desired ester, using sulphuric acid (0.03 mol) as catalyst.

3. Hydrochloric acid (0.03 mol) was found less desirable as a catalyst because it caused a different equilibrium value, presumably through different distribution in the two liquid phases.

4. Practical equilibrium was found to be obtainable by boiling a few hours, using dehydrated alcohols.

5. The water in 95 per cent ethyl alcohol was found to emphasize the separation of the reaction mixture into two layers, which disadvantage can be overcome by increasing the amounts of alcohol and acid and the time of boiling.

6. Methods used at present for the preparation of chaulmoogra ethyl, propyl, butyl, and amyl esters are described and characteristics of these products are given.

7. A method is described for combining the ethyl esters with iodine in such a way as to diminish materially the irritating properties of this drug.

ILLUSTRATIONS

PLATE 1

FIG. 1. Manufacture of chaulmoogra ethyl esters. The reaction is taking place in the two concrete tubs which have condensers attached.
2. Distillation of chaulmoogra ethyl esters. A reserve still, without covering, is placed in foreground to show construction.

TEXT FIGURES

FIG. 1. Experimental preparation of chaulmoogra ethyl esters.
2. Experimental preparation of chaulmoogra propyl esters.

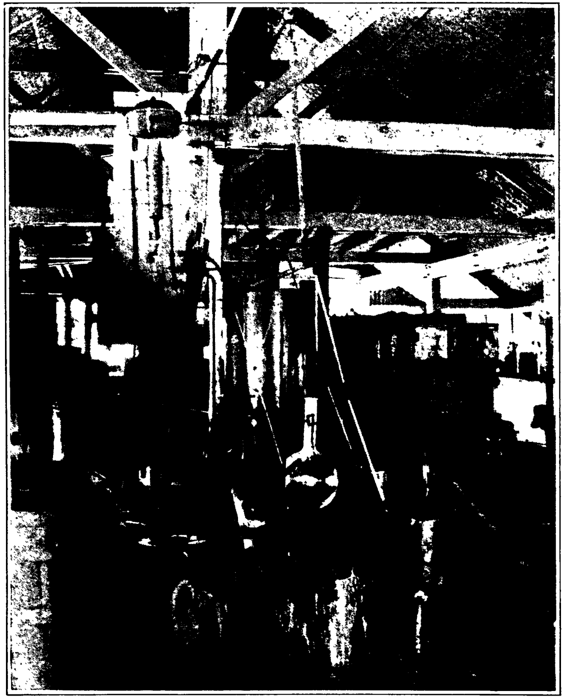

Fig. 1. Manufacture of chaulmoogra ethyl esters. The reaction is taking place in the two concrete tubs which have condensers attached.

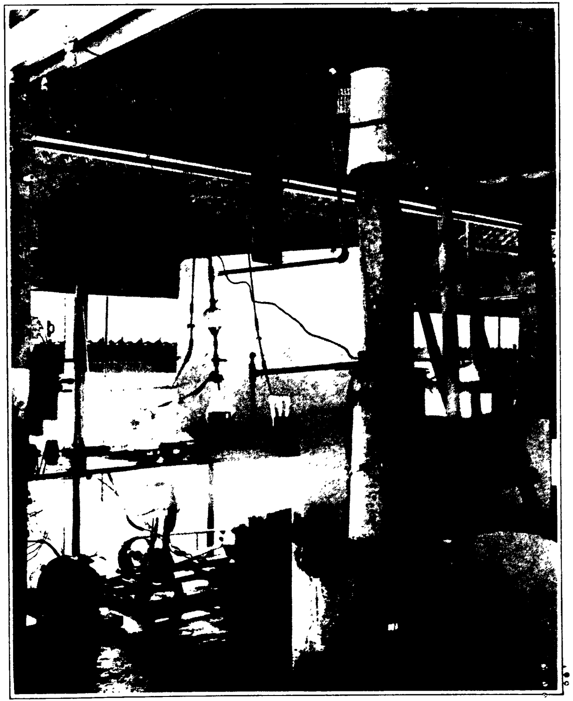

Fig. 2. Distillation of chaulmoogra ethyl esters. A reserve still, without covering, is placed in foreground to show construction.

PLATE 1.

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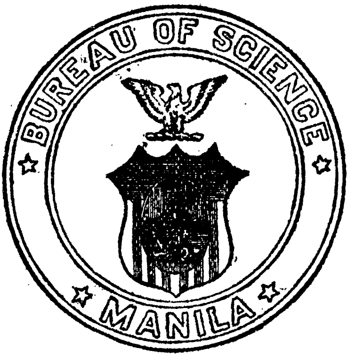

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MALAYAN AND EAST INDIAN BLATTIDÆ, I

INTRODUCTION AND SUBFAMILY PANESTHINÆ

By A. N. CAUDELL

Of the Bureau of Entomology, United States Department of Agriculture

ONE PLATE

INTRODUCTION

The present paper and others expected to follow are based primarily on Blattidæ collected by Prof. C. F. Baker in the Malayan and East Indian Regions and submitted to me for determination and report. Owing to a request that the report be monographic in form, necessitating the inclusion of descriptions of all species occurring in the regions covered and keys, so far as possible, for their separation, it has been thought best to divide the publication into several parts.

In addition to the roaches from Professor Baker there is included in the report the following material:

A small lot of roaches from various places within the regions concerned, loaned for study and determination by the Museum of Comparative Zoölogy, of Cambridge, Massachusetts.

The Blattidæ taken in Java by Bryant and Palmer in 1909 and now in the United States National Museum.

Miscellanous roaches, both named and undetermined, from regions included in this study and now forming a part of the regular collection of the United States National Museum.

The area covered by this report is that comprising the East Indian Islands proper, a region extending from the Philippines on the north to Sumatra and Java to New Guinea on the south, and also the Malay Peninsula to the Isthmus of Kra, but not including the neighboring regions of Siam, Formosa, nor the continent of Australia.

In the construction of synoptic keys characters have been employed, so far as possible, which are easily discernible by the average worker; and through multiple entry where necessary, together with explanatory notes to make clearer certain factors tending to create confusion, it is hoped that the reader may be able to place properly most forms treated. The method of employing the more salient characters and the occasional multiple entrance of units into keys is often frowned upon, but if this treatment results in a more certain location of the diverse forms of roaches included it is certainly justifiable. Synoptic keys are too often constructed and units placed therein regardless of whether or not the characters exhibited conform with those used in the keys. Carelessly constructed keys are worse than useless, and keys without decided alternates are an abomination; thus, such alternates as "*a.* Antennæ with from 17 to 22 segments; *aa.* With from 20 to 30," or "*a.* Size large; *aa.* Size smaller," should be avoided when at all possible.

In systematic grouping it sometimes occurs that a unit is classed with an aggregation from which it is actually (through variation) or apparently (through obscure definition of structure) separated by diagnostic characters used in the keys; in such cases, in the present report, the unit is entered under both alternates, thus, it is hoped, preventing the reader from making unnecessarily numerous misdeterminations.

In a later portion of this series of reports keys will be given for the subdivision of the Blattidæ into subfamilies.

PANESTHINÆ[1]

These are heavy-bodied roaches, varying from apterous to fully winged, with ventrally unarmed intermediate and posterior femora, the anterior ones armed or unarmed, claws without arolia and the supra-anal plate serrate, undulate or entire, not mesially notched; the pronotal disk is always very noticeably and broadly sulcate or depressed and the anterior margin is generally somewhat hoodlike and elevated and sometimes deeply notched; the pronotal disk and dorsal surface of the abdomen are usually noticeably punctate or rugose. The anterior margin of the pronotal disk is often finely pilose, but there is scarcely any danger of confusion with the Corydinæ.

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[1] The following references are of importance in the study of this subfamily: BRUNNER, Ann. Mus. Genova 33 (1893) 45–54; SAUSSURE, Rev. Suisse Zool. 3 (1895) 299–330, pl. 9; KIRBY, Syn. Cat. Orth. 1 (1904) 200–205; HANITSCH, Journ. Straits Branch Roy. Asiatic Soc. No. 69 (1915) 145–158.

The following key will separate the four genera of Panesthinæ occurring in the Malayan and East Indian Regions and also indicates certain roaches of other groups that possess characters causing them to run apparently to this subfamily.

Key to genera of Panesthinæ.

1. Femora armed on cephalic apical margin with two distinct spines (Plate 1, fig. 1). Certain genera of the subfamily Perisphærinæ may fall here, as do certainly the apterous females of the genus *Gymnopeltis*. Members of the subfamily Archiblattinæ, especially immature specimens, may also run out here unless carefully judged.
   Femora unarmed on cephalic apical margin or with a single short spine (Plate 1, fig. 2) .... 2.
2. Seventh dorsal segment of abdomen, that preceding the broad supra-anal plate, laterally serrate or crenulate (Plate 1, fig. 3) .... 3.
   Seventh dorsal segment of abdomen laterally entire or only punctate (Plate 1, fig. 4) .... 4.
3. Both sexes fully winged; fifth dorsal segment of abdomen without lateral projections .... **Salganea Stål.**
   Female at least with only lateral padlike tegmina; fifth segment of abdomen with a small lateral projection .... **Mylacrina Kirby.**
4. Sixth segment of abdomen with the posterolateral angle produced into a sharp point .... **Miopanesthia Saussure.**
   Sixth segment of abdomen with the posterolateral angle not produced or only triangularly so .... **Panesthia Serville.**

Genus **MIOPANESTHIA** Saussure

Miopanesthia SAUSSURE, Rev. Suisse Zool. 3 (1895) 323; KIRBY, Syn. Cat. Orth. 1 (1904) 205; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 156.

The posterolateral angles of the sixth abdominal segment being produced into a sharp spine distinguishes this genus from its allies. The pronotum is scarcely at all notched anteriorly, and the dorsal depression is less profound than in allied genera. The anterior femora are either unarmed or bispinose ventrally. Adults are probably always fully winged. Supra-anal plate apically entire or denticulate. The two species found in the regions concerned may be separated as follows:

Key to species of Miopanesthia Saussure.

1. Anterior femora armed beneath with two distinct spines; supra-anal plate apically entire; tarsi very slender, the posterior metatarsus as long as the rest of the segments combined .... **M. stenotarsis Saussure.**
   Anterior femora unarmed beneath; supra-anal plate apically dentate; tarsi not noticeably slender .... **M. discoidalis Saussure.**

Miopanesthia discoidalis Saussure.

Miopanesthia discoidalis SAUSSURE, Rev. Suisse Zool. 3 (1895) 326; KIRBY, Syn. Cat. Orth. 1 (1904) 205; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 157.

No specimen of this species has been seen. The type of this species as noted in the original description is probably an immature specimen, being a small apterous roach described from Java and India. Of undoubtedly adult specimens in this genus males only have been reported, and it is questionable just what the adult female is. In fact, the type of the present species may be adult, the male only being winged. Biological investigation or more extensive collection of material will have to settle this point. The original description of *M. discoidalis* is as follows:

♀. Ovata, convexa, nitida, fusco-nigra vel rufescens; antennis pedibusque rufo-testaceis. Thorax et abdominis basis politi, subtiliter sparse punctulati. Pronoti margo anterior reflexus, minute trigonali-incisus; angulis incisurae trigonali-erectis. Depressio anterior retro rotundato-producta; disco proter hoc antice depressionem rotundatam obferente; haec marginibus et linea media subtiliter lineatim granulosis; area antica striolatorugulosa; anguli postice fere rectanguli. Abdomen posterius cribroso punctatum, angulis 6i te 7i segmenti breviter acute productis. Lamina supraanalis margine toto denticulato (denticulis 12–14). Femora antica subtus inermia. Long. 19 mm. (Immatura? aptera). Hab: Java, India.

Miopanesthia stenotarsis Saussure.

Miopanesthia stenotarsis SAUSSURE, Rev. Suisse Zool. 3 (1895) 325, pl. 9, fig. 2; KIRBY, Syn. Cat. Orth. 1 (1904) 205; HANITSCH, Journ. Str. Roy. Asiatic Soc. No. 69 (1915) 157.

This is a small black roach of which only the male has been seen. The original Latin description of the insect is as follows:

♂. Minuta, gracilis, nigra; antennis, ore, ocellis pedibusque rufis. Caput prominulum, politum. Pronotum nitidum, politum, depressum, haud gibbosum, subtiliter sparse punctulatum, tuberculis nullis; margine antico late truncato, plano, haud reflexo. Disci impressio angusta, elongata, retro-acuminata, haud rugosa; pars postica pronoti in medio foveolis 2 ovatis transversis notata. Margines laterales valde arcuati, angulis rotundatis. Elytra sat angusta, abdominis longitudine vel abdomen paulum superantia; castanea, venosa, basi punctata. Alae fuscae, apice parabolice rotundatae. Pedes gracilis. Femora antica bispinosa. Tibiarum spinae graciles ac longae. Tarsi gracillimi; posticorum metatarsus reliquis articulis aequilongus. Abdomen supra ac subtus sat dense, haud grosse punctatum, segmentis 2–5 supra basi prozonam angustam politam et sulcum transversalem obferentibus. Segmenta 6m, 7m angulis spiniformiter productis, spinis 6i quam illae 7i longioribus. Lamina supraanalis minuta, brevis, transversa, polita, vix punctata, margine postico leviter arcuato, utrinque lobo obsoleto. Cerci trigonales acuti. Ultimum segmentum ventrale truncatum. Lamina infragenitalis polita, parum prominula, margine arcuato.—Java.

Long. corp.	♂ 21 mm.
Elytra	18 "
Pronotum	4.6 mm.
latit. pron.	6.3 "
latit. abd.	8.5 "

Hanitsch[2] adds the following note:

A specimen (♂) which I took on Mt. Poe, Sarawak, 3500′, April 1913, is probably referable to this species. The spines of the 6th and 7th segments are well marked. Its dimensions are as follows:

total length.	♂ 30 mm.
body, length	25 "
pronotum, length	7 "
pronotum, breadth	9 "
tegmina, length	25 "

Three adult males have been examined in the present study, all from Tjibodas, Java (*Barbour*) (Museum of Comparative Zoölogy). Also three nymphs from the same locality, Mount Gede, April 20, 1909 (*Bryant and Palmer*), are referred here; two of these are large females, and may really be adults, and one is a small male; the two females have the pronotum smooth and even on the disk, which is posteriorly truncate.

Genus **MYLACRINA** Kirby

Mylacrina KIRBY, Ann. & Mag. Nat. Hist. VII 11 (1903) 414; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 158.

This genus is based on the female sex only and the description is as follows:

Female.—Front of pronotum bordered by a raised rounded ridge, deeply and triangularly excavated in the middle; the surface rugose, the sides thickly punctured; two broad converging ridges running towards the raised hinder portion, which is furnished with a large tubercle on each side in front, and two in the middle; halfway between the front and hinder tubercles is a shallow depression. Upper surface of body sparingly punctured, except on the sides; but the sixth segment of the abdomen with large and numerous punctures; the seventh coarsely, and the terminal plate more finely, rugose. Fifth and sixth segments of the abdomen with distinct, though small, projecting lateral angles, that on the seventh larger, and slightly oblique, seventh segment twice slightly indented; terminal plate with numerous short blunt teeth. Tegmina lateral, subtriangular, rounded at the extremity, not much longer than the pronotum, and with large and numerous punctures. Wings not visible. Front femora with a strong curved spine at the extremity of the inner carina. Cerci short, rounded, set with fine reddish hair.

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[2] Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 157.

Differs from typical *Dicellonotus, Macropanesthia* &c. in the presence of short tegmina, in the lateral projections on segments 5 and 6, &c.

Mylacrina wrayi Kirby.

Mylacrina wrayi KIRBY, Ann. & Mag. Nat. Hist. VII 11 (1903) 141; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 158.

The following brief description is quoted from Kirby:

> *Female.*—Black; antennæ, knees, and tarsi dark ferruginous, scape of antennæ, mouth-parts, and pulvilli lighter reddish, upper part of head black, smooth and shining, with a few very fine punctures.
>
> *Hab.* Perak (*Wray*).

No specimen of this Bornean roach has been seen, nor has it been reported from material other than that upon which the species was based.

Genus **PANESTHIA** Serville

Panesthia SERVILLE, Hist. Nat. Ins. (1839) 130; KIRBY, Syn. Cat. Orth. 1 (1904) 202; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 147.

Caeparia STÅL, Oefv. Vet. Akad. Forh. 24 No. 10 (1877) 37; KIRBY, Syn. Cat. Orth. 1 (1904) 201.

From the other panesthinæan genera this, the typical genus, is distinguished by the smooth lateral margins of the seventh segment of the abdomen and the nonproduced or but slightly produced posterolateral margins of the sixth segment. There is much variation in most characters exhibited by various species of the genus; thus the fore femora may be either unarmed beneath or armed with from one to four or even five distinct spines, the organs of flight are present and fully developed or abbreviated or entirely absent and the supra-anal plate may be apically undulate, serrate, or crenate or entirely smooth. The size ranges from very large insects to rather small ones. Most species are unicolorously black, but a few are rather brightly variegated.

According to rules of nomenclature, including opinion 65 of the International Commission, *Panesthia mandarina* Sauss., being the only included species, is the type of Stål's genus *Caeparia* which relegates that genus to the synonymy under *Panesthia.* The genus of which the species correctly known as *P. saussurei* Wood-Mason[3] is the type is thus without a name. For this the new name **Neocaeparia** is here proposed.

The following key, based primarily on those of former workers, contains so far as it has been possible to enter them all, species of *Panesthia* coming within the scope of the present study. A few species are interpolated in the key next to species with which they appear to be related but from which they cannot be separated for lack of specimens or adequate descriptions. A couple are listed at the end as unplaced.

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[3] Journ. Asiatic Soc. Bengal 45 (1876) 190.

Key to species of Panesthia Serville.

1. Supra-anal plate apically dentate, crenate or undulate .... 2.

Supra-anal plate apically entire .... 19.

2. Legs ferruginous. (A small apterous form, very likely the immature stage of some larger species.) .... **P. ferruginipes Brunner.**

Legs black or blackish, or femora and coxæ reddish .... 3.

3. Tegmina unicolorously black or brown, rarely absent .... 4.

Tegmina distinctly bicolored, never absent .... 15.

4. Anterior femora armed beneath with two to four distinct spines, small in nymphs .... 5.

Anterior femora unarmed beneath, rarely armed with a single spine.. 14.

5. Lateral margins of seventh abdominal segment incised at the base of the posterolateral tooth and the tooth obliquely divergent. (The character of divergent posterolateral tooth of the seventh abdominal segment suggests that this form should be referred out of this genus; however, as no specimens have been seen, it is thought best to follow previous writers in placing it here.) .... **P. serratissima Brunner.**

Lateral margins of seventh abdominal segment not incised at base of posterolateral tooth, and tooth directed backward .... 6.

6. Tegmina fully developed but often broken partly away .... 7.

Tegmina abbreviated or absent .... 11.

7. Pronotal disk anteriorly conspicuously notched, the angles of the notch hornlike in male and tubercular in female .... 8.

Pronotal disk anteriorly slightly emarginate in male, in female scarcely at all. (Pronotal disk unequal but without elevated tubercles.)
P. angustipennis Illiger.

8. Head black .... 9.

Head light reddish .... **P. ruficeps Kirby.**

9. Size smaller, length seldom over 35 or 36 millimeters.
P. saussurei Stål.

Size larger, usually 40 or more millimeters in length .... 10.

10. Usually slightly larger and the color shiny black .... **P. æthiopis Stoll.**

Usually slightly smaller and the color of tegmina with a reddish tinge, usually distinct when looked at in the right light but sometimes rather obscure .... **P. javanica Serville.**

(*P. kheili* probably falls under this section but may fall under section 5 with *serratissima.*)

11. Tegmina strongly abbreviated but meeting above.
P. brevipennis Brunner.

Tegmina lobiform, lateral .... 12.

12. Tegmina noticeably deep red-brown .... **P. mearnsi sp. nov.**

Tegmina black .... 13.

13. Antennæ apically yellowish; pronotal disk nearly smooth.
P. lobipennis Brunner.

Antennæ wholly black; pronotal disk strongly rugose.
P. mearnsi var. uniformis var. nov.

14. Tegmina fully developed.. **P. puncticollis Stål.**
Tegmina lobiform, lateral.. **P. biglumis Saussure.**
(*P. sinuata* Sauss. comes here also.)

15. Tegmina yellowish with costal margin black, a moderately large black spot on basal half, and apical half almost wholly occupied by a larger black spot, the two spots either united or separate.
P. ornata Saussure.
Tegmina not as above.. 16.

16. Tegmina wholly reddish brown except extreme base and more than basal half of the broadened portion of costal margin, where the color is piceous; wings entirely reddish brown........ **P. bakeri sp. nov.**
Tegmina not as above.. 17.

17. Tegmina dark brown with an oblique yellowish stripe which does not cover anal field; wings infuscated................ **P. transversa Burmeister.**
Tegmina with a broad, brownish or dirty white stripe, which covers anal field; wings subhyaline, the basal half infuscated.................. 18.

18. Black; tegminal bands whitish; pronotum anteriorly sinuate.
P. mandarinea Saussure.
Brown; tegminal bands sordid; pronotum of female entire, or very slightly sinuate.. **P. bramina Saussure.**

19. Anterior femora unarmed beneath........................ **P. celebica Brunner.**
Anterior femora armed beneath with one or two distinct spines........ 20.

20. Both sexes fully winged; size large, length over 35 millimeters.
P. wallacei Wood-Mason.
Apterous, at least the female; smaller, length less than 35 millimeters.
P. polita Krauss.

Unplaced, *P. conica* Walker and *P. hilaris* Kirby.

Panesthia æthiopis Stoll.

Blatta æthiopis STOLL, Spectres, Blatt. (1913) 3, pl. 1*d*, fig. 3.
Panesthia aethiopis KIRBY, Syn. Cat. Orth. 1 (1904) 202.

Nine adult specimens, 5 males and 4 females, present from the Philippine Islands as follows: 4 males and 2 females, Mount Apo, Mindanao, June and July (*E. A. Mearns*) ; 1 male, Dapitan, Mindanao, (*Baker 10337*) ; 1 female, Guimaras, J. B. Steere Expedition; 1 female, Polillo, Taylor, collector (*Baker 18670*).

There are also numerous nymphs of various sizes belonging here or to *P. javanica.* The distinctness of these two species is rather doubtful and the recognition of both names is thought best by reason of the fact that otherwise *P. javanica,* an old and much-used name, would fall into the synonymy under an older but very little-used name. Thus, *P. æthiopis* is here listed as distinct, as it was by Kirby, who writes of it as follows: "This is a much larger and darker insect than the common

P. javanica, Serv., with which it is usually considered to be synonymous." [4]

Panesthia angustipennis Illiger.

Blatta angustipennis ILLIGER, Mag. Insekt. 1 (1801) 185.

Panesthia angustipennis BRUNNER, Syst. Blatt. (1865) 395; KIRBY, Syn. Cat. Orth. 1 (1904) 202; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 149.

Brunner gives the following rather brief description of this species:

Pronoti incisurâ in mare parum profundâ, latere et medio dentatâ; feminae vix impressione indicatâ, dentibus nullis. Elytris nitidissimis, corporis longitudine. ♀ ♂.

long.	♂	♀
corporis	37 mm.	34 mm.
pronoti	8 "	7.5 mm.
Pron. trans.	13 "	12 "
Elytrorum	31 "	30 "

Hab: Borneo; Philippines; Amboina (Brunner). Sumatra (Kirby).

Three adult males seen, 1 from Los Baños, P. I. (*Baker 10340*), and 2 from Mount Salak, Java, 2,500 feet altitude (about 800 meters) (*Bryant and Palmer*).

Panesthia bakeri sp. nov.

? *Panesthia mandarinea* HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 149, pl. 6, fig. 33, male (not female).

Description.—Female, the male unknown. Color wholly piceous except the lower border of clypeus and labrum and the pulvilli, which are light, and the tegmina and wings which are reddish brown, the former with the extreme base and the expanded portion of costal margin for more than half its length black; the eyes are slightly lighter than the rest of the head; antennæ wholly black. Anterior femora armed beneath with two stout spines; supra-anal plate with seven scallops (Plate 1, fig. 4); pronotal disk with rather deep depressions as is common in the genus but the surface not strongly rugose or pitted, anterior margin moderately notched; lateral margins of the seventh segment of abdomen with the posterolateral angle forming an elongate triangular point, apically sharply pointed and curved slightly inwards (Plate 1, fig. 4).

Measurements: Length, 34 millimeters; pronotum 6.5; tegmina, 26; width, pronotum, 10.

Type, 1 female labeled: "Luzon Benguet, Baguio" (*Baker 10341*).

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[4] Ann. & Mag. Nat. Hist. VII 11 (1903) 412.

Type in United States National Museum, catalogue No. 25644. The specimen noted and the figure by Hanitsch in the above cited reference may be the male of this species, or *P. bakeri* may represent a color phase of *P. mandarinea.* For a discussion of this matter see *P. mandarinea,* page 654.

Panesthia biglumis Saussure.

Panesthia biglumis SAUSSURE, Rev. Suisse Zool. **3** (1895) 319; KIRBY, Syn. Cat. Orth. 1 (1904) 203; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 150.

♀. Minuta, nigra. Antennæ ferrugineæ. Pronotum impresso-punctatum, tuberculis centralibus minimis vel nullis, invicem remotis; area antica valde granulata; margine antico medio arcuato-inciso; angulis plus minus acutis, trigonalibus, erectis fere retro-reflexis; angulis posticis pronoti rectangulis. Elytra squamiformia, lateralia, dimidium metanotum superantia, apice rotundato. Alæ angustissimæ, sub elytra reconditæ, tantum apice perspicuæ. Abdomen politum, sparse punctatum; segmentum 7^m et lamina supraanalis crasse irregulariter punctata ac rugata; segmentum 7^m basi utrinque profundissime impresso-foveolato-punctatum. Lamina supraanalis dense rugata, subexcavata, margine postico dense multi-denticulato, denticulus hebetatis, 8–10, ad inferum deflexis, dente laterali plus minus acuta. Ultimum segmentum ventrale biimpressum, dense rugosum, plicis lateralibus longis, deflexis, ipsis dense rugosis. Femora antica subtus inermia. Long. 25,5–27; pronot. 6,5–7,5; latit. 10–10,5; elytr. 4,5–6 mm.
Hab. India; Sikkim (Mus. Calcuttae) (Saussure).—Java?—(Kirby).

This species is not represented in the material studied.

Panesthia bramina Saussure.

Panesthia bramina SAUSSURE, Rev. Suisse Zool. **3** (1895) 322; KIRBY, Syn. Cat. Orth. 1 (1904) 203; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 156.

♀. Nigra vel rufescens. Pronotum transverse ellipticum, breve, dense cribroso-punctatum, tuberculis nullis; margine anteriore truncato, in medio minute subinciso, linea elevata (♀) nulla. Elytra angusta, abdominis longitudine, basi castanea, dehinc vitta lata transversa completa sordide decolore, apicem campi analis tegente; dimidia parte apicali elytri subhyalina, ad vittam luteam fusco-ferruginescente. Alæ fusco-ferrugineæ, tertia parte apicali hyalinæ. Femora anteriora haud spinosa. Abdomen crasse remote impresso-punctatum. Septimi segmenti anguli breviter spinosi. Lamina supraanalis densius punctata, margine postico rotundato-crenulato, utrinque angulo hebetato prominulo. Long. 35; pronot. 7; latit. 12; elytr. 29,5 mm.
Var. Nigra, vitta elytrorum distinctius delineata, canescens?
♂ Pronotum antice leviter sinuatum.
Hab: India; Johore.

No specimens seen.

Panesthia brevipennis Brunner.

Panesthia brevipennis BRUNNER, Ann. Mus. Genova **33** (1893) 51; KIRBY, Syn. Cat. Orth. **1** (1904) 203.

Brunner's description of this species is as follows:

Pronotum margine antico leviter late rotundato-emarginato, disco planiusculo, tuberculis duobus centralibus minimis instructo, angulis lateralibus obtusis. Elytra abbreviata, segmentum abdominale primum non superantia. Femora antica subtus 2 vel 3-spinulosa. Lamina supraanalis 6-crenulata. ♂.

long. corporis	♂ *34 mm.*
" pronoti	" *7,5*
lat. pronoti	" *11,2*
long. elytrorum	" *12*

Patria: Amboina (coll. m.).

This species not seen.

Panesthia celebica Brunner.

Panesthia celebica BRUNNER, Ann. Mus. Genova **33** (1893) 53; KIRBY, Syn. Cat. Orth. **1** (1904) 204.

This species, which is not represented in the material studied, is described by Brunner as follows:

Statura magna. Colore atro. Pronotum margine antico reflexo et obtuse triangulariter emarginato, disco quadri-tuberculato, tuberculis binis anticis altioribus, acuminatis. Elytra perfecte explicata (in exemplo unico praesente mutilata). Pedes atri. Femora antica subtus mutica. Segmentum abdominale dorsale septimum plica transversa curvata instructum. Lamina supraanalis valde transversa, margine postico integro. ♀

long. corporis	♀ *57 mm.*
" pronoti	" *13,5*
lat. pronoti	" *19,5*
long. elytrorum	*?*

Patria: Insula Celebes septentrionalis (coll. m.).

Panesthia conica Walker.

Panesthia conica WALKER, Cat. Blatt. Brit. Mus. (1868) 23; KIRBY, Syn. Cat. Orth. **1** (1904) 204.

This has never been reported since the original description. Kirby leaves it in this genus with a question, and it is very likely an immature form. Following is the original description:

Female. Larva.—Reddish tawny, finely punctured, increasing in breadth from the head to the fifth abdominal segment. Head roughly punctured towards the mouth, near which there is a blackish band. Prothorax hardly narrower in front; borders not reflexed; sides slightly rounded; disk with two deep oblique furrows which converge hindward; hind border hardly sinuated. Mesothorax and metathorax with the hind angles rounded and slightly elongated. Abdomen roughly punctured towards the tip, where the border is serrated. Fore femora armed beneath with three spines. Length of the body 13 lines.

The dilated abdomen and other characters sufficiently distinguish it from *P. rufa.*

a. Java. From Mr. Argent's collection.

Panesthia ferruginipes Brunner.

Panesthia ferruginipes BRUNNER. Ann. Mus. Genova 33 (1893) 53; KIRBY, Syn. Cat. Orth. 1 (1904) 202; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 152.

No specimens have been seen referable to this form. This wingless roach may be the nymph of some winged form. The original description is as follows:

Statura minore. Aptera. Atra, tota impresso-punctata, antennis pedibus et cercis ferrugineis. Pronotum parvum, planum, margine antico rotundato, haud emarginato, tuberculis nullis. Femora antica inermia. Lamina supraanalis multi-crenulata. ♂.

long. corporis	♂	*18,5 mm.*
" pronoti	"	*5*
lat. pronoti		*7,5*

Patria? (coll. m.).

Panesthia hilaris Kirby.

Panesthia hilaris KIRBY, Ann. & Mag. Nat. Hist. VII 11 (1903) 413; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 153.

While, as shown by the following original description quoted from Kirby, this species is described rather fully, it cannot be placed in the key to species, and so is listed at the end. No specimen referable to this form has been found.

Long. corp. 32 millim.; exp. tegm. 62. millim.

Female.—Head smooth, black, face with a few fine punctures, eyes, ocelli, and antennal pits yellow, lower mouth-parts reddish, antennæ black, with a ring formed of two yellow joints at three fourths of their length; thorax above dark chestnut-brown, shading into blackish in front, except at the sides; metathorax light reddish; abdomen mostly black; under surface and legs mostly reddish chestnut. Prothorax with a rounded concavity on the frontal margin, leaving the vertex visible; front of prothorax sparingly punctured, with three shallow carinæ, the middle one very fine, converging behind, where a shallow lyrate depression, sparingly punctured, separates the front of the pronotum from the slightly raised and more thickly punctured hinder part. Front femora with a terminal spine beneath, and a preceding one on the left femur; pulvilli yellow. Abdomen with large depressed punctures; the terminal plate with larger and fewer punctures, the margin somewhat flattened, the extremity rounded. Tegmina yellowish hyaline, the basal third and a spot on the middle of the costa of the right tegmen, corresponding to a stripe on the left tegmen not reaching the inner margin; wings yellowish hyaline, darker towards the base, and lurid towards the costa.

Hab. Sandakan (*Creagh*).

Panesthia javanica Serville.

Panesthia javanica SERVILLE, Ann. Sci. Nat. 22 (1831) 38; KIRBY, Syn. Cat. Orth. 1 (1904) 202; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 147, pl. 6, fig. 34.

The nymphs of this common form, with the mesonotum and metanotum each marked by two yellow spots, are more conspicuous than the more somber-colored adults. As noted in discussion on a previous page under *Panesthia æthiopis* Stoll, the present species and *P. æthiopis* are very closely related and the nymphs have not been separated. The characters used in the key will generally serve to distinguish this roach from its allies. The tegmina being with a slight reddish brown cast will usually distinguish it from the more uniformly dead black-colored *P. æthiopis*. Kirby says *æthiopis* is larger, but this is seldom very obviously true.

Six adults are referred to *P. javanica*, 1 male and 5 females as follows:

One male, Mount Maquiling, Luzon, P. I. (*Baker 10388*); 1 female, Malinao, Tayabas, P. I. (*Baker 5470*); 1 female, Buitenzorg, Java, April to December, 1896 (*D. G. Fairchild*); 1 female, Megamendg Mountains, Java, altitude 4,800 feet (about 1,460 meters), (*Bryant and Palmer*); 1 female, Buitenzorg, Java (*Bryant and Palmer*); 1 female, Kinabalu, Borneo; also many nymphs of various sizes belonging here or to *P. æthiopis*.

Panesthia lobipennis Brunner.

Panesthia lobipennis BRUNNER, Ann. Mus. Genova. 33 (1893) 51; KIRBY, Syn. Cat. Orth. 1 (1904) 203; BRUNER, Univ. Studies, Lincoln, Nebr. 15 No. 2 (1915) 31.

The single record entitling this species to entrance in the present consideration is the one listed above by Bruner, where it is recorded from Lamao, Bataan Province, Luzon. It seems rather possible that the specimens on which this record is based might have been the form described on page 655 of the present paper as *P. mearnsi uniformis* var. nov. Specimens of *P. lobipennis* from the type locality, Ceylon, are available for study, and nothing referable to it was found in the collections forming the subject of the present paper except the var. *uniformis* here noted, which might readily be mistaken for *lobipennis* by anyone without specimens of both forms for comparison.

The original description of *P. lobipennis* reads as follows:

Pronotum margine antico leviter late emarginato, angulis emarginationis tuberculatis, disco planiusculo, tuberculis duobus sat remotis, margine postico truncato, angulis acutiusculis. Elytra lobiformia, lateralia. Femora antica subtus bispinulosa. Lamina supraanalis 3-crenulata. ♂.

long corporis	♂ *30 mm.*
" *pronoti*	" *8*
lat. pronoti	" *11,5*
long. elytrorum	" *3*

Patria: Insula Ceylon (coll. m.).

Panesthia mandarinea Saussure.

Panesthia mandarinea SAUSSURE, Mem. Soc. Genève 17 (1864) 168, pl. 1, fig. 25; MELICHAR Orth. 1 (1870) 106, pl. 3, fig. 23; KIRBY, Syn. Cat. Orth. 1 (1904) 204; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 149, female; ? (id. pl. 6, fig. 33, male).
Caeparia mandarinea STÅL. Oefv. Vet. Akad. Forh. X 34 (1877) 37.

Saussure originally described this species as follows:

Nigra, nitida, capite prominulo; pronoto brevi et lato, grosse punctato, incisura lata instructo, utrinque tantum subcornigero, sulco profundo, late arcuato; elytris sat angustis, basi nigris, fascia media albida, dein fuscescentibus, apice unicoloribus.

It is not at all certain that this species should have a place in the present paper, as the male described and figured by Hanitsch from Sarawak at the reference cited above, may be *P. bakeri* described on page 649 as a new species. This, however, is not at all sure, the greater expanse of black at the base of the tegmina indicating otherwise. The subuniform coloration of the distal portion of the tegmina, however, suggest *P. bakeri* rather strongly. It may, indeed, result finally that *mandarinea* and *bakeri* represent a range of variation, in which case the latter will fall to varietal rank.

For a discussion of *mandarinea* as the type of *Caeparia* Stål see under the genus *Panesthia* on page 646.

Panesthia mearnsi sp. nov.

Description.—Male and female. Of rather small size, shining black, both above and beneath, with the tegmina deep red-brown. Head not quite concealed beneath pronotum, entirely black except the extreme tips of palpi and usually the lower margin of clypeus, which are lighter or reddish. Pronotal disk strongly depressed in anterior half as usual, a rounded elevation on either side of ventral depression and a pair of distinctly elevated tubercles on anterior part of posterior raised portion; anterior margin elevated and mesially rather deeply notched, about the same in both sexes. Tegmina extending barely beyond apex of mesonotum, about two and one-half times as long as broad, apically rather narrowly rounded, both margins slightly convex, the whole very gradually tapering (Plate 1, fig. 5); wings absent. Anterior femora unarmed beneath, in one specimen with a single spine on each. Supra-anal plate with apical margin gently sinuate (Plate 1, fig. 6).

Measurements: Total length, male, 27 to 32 millimeters; female, 30; pronotum, male, 7 to 8 millimeters; female, 8; tegmina beyond pronotal disk, male, 4 to 5 millimeters; female, 4 to 5; width, pronotum, male, 10 to 11 millimeters; female, 10.5; tegmina at middle, male, 2.5 to 3 millimeters; female, 2.5.

Described from seven adult specimens, all from Luzon, P. I., July, 1907, taken by the late Dr. E. A. Mearns, in whose honor the species is named. Five of the specimens are males, of which one of the middle-sized is designated type and the others as paratypes A, B, C, and D; of the two females, one is designated allotype and the other paratype E. Type material in United States National Museum, catalogue No. 25625.

This species appears rather distinctive by reason of the reddish brown tegmina, which are conspicuous against the black mesonotum. It does not appear to be very nearly related to any described species, though in some ways it is allied to *P. lobipennis,* especially as noted below under var. *uniformis.*

Panesthia mearnsi var. **uniformis** var. nov.

Description.—Female, the male unknown; similar to the typical form except that the tegmina are uniformly piceous, being concolorous with the rest of the body, and the anal margin is less convex, being almost straight with a slight basal swelling (Plate 1, fig. 7). The reddish band bordering the clypeus is absent, but this apparently signifies little as it is almost absent in one or two specimens of the typical form. Anterior femora unarmed beneath and the supra-anal plate as in the typical form.

Measurements: Total length, 28 millimeters; pronotum, 7; tegmina, beyond pronotum, 3.5; width, pronotum, 10 millimeters; tegmina at middle, 2.

Described from a single specimen, a female from Mount Halcon, Mindoro, P. I., 1906 (*E. A. Mearns*). This is the type and it is in the United States National Museum, catalogue No. 25626.

This variety, with its piceous tegmina, is very like *P. lobipennis* and may, indeed, be the species recorded by Bruner from Luzon as that species. *Panesthia lobipennis,* however, has the pronotal disk much smoother than has the present form, the anterior femora are armed beneath with one or two spines, and the supra-anal plate has but three sinuations apically while in *P. mearnsi* there are from five to seven. In specimens of *P. lobipennis* in the United States National Museum collection from Ceylon the antennæ are distally yellowish, which is not true of *P. mearnsi.*

Panesthia ornata Saussure.

Panesthia ornata SAUSSURE, Mem. Soc. Genève **33** (1872) 152, pl. 10, fig. 54; KIRBY, Syn. Cat. Orth. **1** (1904) 203; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 154.

The coloration of the tegmina of this handsome little species will serve for its ready recognition; it consists of a yellow background with a large oval black spot occupying most of the distal half of the surface, and another about half as large in the proximal half, sometimes merging with the larger one; the base of the costal margin also is black. The rest of the insect is entirely and uniformly black. The size varies from about 20 to 25 millimeters.

Ten specimens of this roach are present, 5 males and 5 females, all from Baguio, Benguet (*Baker 16407*).

Panesthia polita Krauss.

Panesthia polita KRAUSS, Semon Zool. Forsch. Austr. Mal. Arch. **5** (1903) 754; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 151.

This species, of which no specimen has been seen by me, is described as follows by Krauss:

Statura parva, elongato-ellipsoidea, convexa. Nigra, nitida, punctata. Caput a pronoto parum obtectum, subtilissime punctatum, antennis, clypeo, labro palpisque ferrugineis, maculis ocelliformibus flavis. Pronotum semiorbiculare, postice rotundatum (♂) vel in medio subtruncatum (♀), convexum, haud impressum, subtiliter punctatum, margine laterali parum elevato. Meso- et metanotum impresso-punctata, marginibus lateralibus subelevatis, in ♀ postice late rotundatim emarginata, angulis lateralibus obtusis. Elytra alæque in ♀ nullæ, in ♂? Pedes subtilissime punctati, subglabri. Femora antica subtus bispinulosa. Abdomen impresso-punctatum, tergitis utrinque spinoso-productis, subtus basi rufo-castaneum. Lamina supraanalis ♂ ♀ impresso-punctata, postice sulco intramarginali et utrinque lobulo acuto instructa, margine integro. Cerci trigonales, acuti, rufo-castanei. Lamina subgenitalis ♂ parva, semilunaris, obsolete punctata, ♀ magna semiorbicularis, impresso-punctata.

	♀	
Longitudo corporis	22—25	mm
” pronoti	4,5—6	”
Latitudo ”	6,5—8	”

Vorkommen: Tjibodas (Java), Borneo (Collectio mia).

Panesthia puncticollis Stål.

Panesthia puncticollis Stål, Oefv. Vet. Akad. Forh. 34 No. 10 (1877) 37; Kirby, Syn. Cat. Orth. 1 (1904) 203.

The original description is as follows:

Præcedenti (*P. Saussurii*) simillima, sed pronoto ubique sat fortiter punctato, elytris anterius punctis raris distinctioribus conspersis, et basi in area anali punctis majoribus et numerosioribus instructis, area costali pone medium pallescente; femora antica inermia. ♀. Long. corp. 23 mm.

No specimen of this species has been found in the material examined.

Panesthia ruficeps Kirby.

Panesthia ruficeps Kirby, Ann. & Mag. Nat. Hist. VII 11 (1903) 412; Hanitsch, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 148.

This species, of which no specimen has been seen in the present study, is described by Kirby as follows:

Size, shape, and general appearance of *P. javanica*, Serv.; front femora likewise trispinose, and the punctuation very similar. Differs as follows:—Dark brownish red, instead of black mixed with red; the centre of the pronotum, the terminal plate of the abdomen above and below, and the labium shading into blackish. Head otherwise light red (black in typical *P. javanica*), smooth and shining, clypeus below transversely striated. Tegmina rather lighter chestnut than in *P. javanica*. Pronotum in front with a distinct central carina in the male, but scarcely more excavated in front in the male than in the female.

Larva with more or less distinct oblique red marks on the meso- and metanotum, often curving round behind into a continuous band, and frequently with additional red marks on the sides.

Hab. Christmas Island.

Panesthia saussurei Stål.

Panesthia saussurei Stål, Oefv. Vet. Akad. Forth. 34 No. 10 (1877) 37; Kirby, Syn. Cat. Orth. 1 (1904) 202.

The original description is as follows:

P. javanicæ simillima, sed minor, lateribus pronoti fortius punctatis, elytris anterius punctis subtilibus raris conspersis, abdomine minus dense punctato, angulis apicalibus laminæ supraanalis obtusioribus; femora antica variant inermes, vel spinis duabus vel una armata. ♂ ♀. Long. corp. 26–32 mill.

A single specimen of this roach occurred in the collections studied, a male from Baguio, Benguet, P. I., Baker No. 10399. This is very like *P. æthiopis* and *P. javanica* except for the smaller size. It may eventually prove to be a diminutive form of one of these larger species.

Panesthia serratissima Brunner.

Panesthia serratissima BRUNNER, Nouv. Syst. Blatt. (1865) 394; KIRBY, Syn. Cat. Orth. 1 (1904) 203.

The original description is as follows:

Minor. Mas pronoti incisura profunda; femina margine antico pronoti vix emarginato. Segmento ultimo dorsali abdominis, ante angulos posticos, acute sinuato, dente terminali subincurvo, lamina supraanali dentibus confertissimis. Larva tota nigra. ♂ ♀.

Long	maris et fem.
Corporis	25 mm
pronoti	5,5 "
Pron. transv.	8 "
elytrorum	23 "

Not found in the collections studied.

Panesthia sinuata Saussure.

Panesthia sinuata SAUSSURE, Rev. Suisse Zool. 3 (1895) 318; KIRBY, Syn. Cat. Orth. 1 (1904) 203; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 155.

The original description is quoted as follows by Hanitsch:

♂ minuta, nigra. Pronotum utrinque crasse punctatum, tuberculis centralibus trigonalibus, acutis; area depressa antica utrinque granulata, in medio carinulata, margine anteriore late sinuato, angulis rotundatis carina præ-marginali instructo; marginibus lateralibus subrectis, (utrinque sinu notatis); cum marginibus anterioribus angulum obtusum efficientibus; angulis posticis obtusangulis. Elytra condite explicata, basi punctata. Femora anteriora spinis nullis. Abdomen crassime impresso-punctatum; 7i segmenti dentes apicales parum acuti, divergentes scilicet margine laterali segmenti ad dentem distincte obtusangulatim sinuato. Lamina supraanalis margine obtusissime obsolete undato, lobulis 4; angulis lateralibus obtusis. Venter apice crassissime punctatus.—Long. 24,5; pronot. 5,8; latit. 8,5; elytr. 20 mm.

Singapore.

No specimen referable to this form has been seen.

Panesthia transversa Burmeister.

> *Panesthia transversa* BURMEISTER, Handb. Ent. 2 (1838) 513; BRUNNER, Ann. Mus. Genova **33** (1893) 51; KIRBY, Syn. Cat. Orth. 1 (1904) 203; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 154.

No specimen of this species has been seen. Brunner's description, which is also quoted by Hanitsch, follows:

Antennæ apice flavæ. Pronotum ♂ margine antico late et profunde sinuato, sinu medio tuberculato, angulis in cornua incurva productis, ♀ margine antico truncato. Elytra atra, in tertia parte basali fascia obliqua, lata, pallide flava ornata. Pedes atri. Femora antica subtus inermia. Segmentum abdominale, dorsale septimum margine postico integro, limbato. Lamina supraanalis indistincte crenulata. ♂ ♀.

long. corporis	♂ *34*	*mm.*	♀ *30*	*mm.*
" *pronoti*	" *6,5*		" *5,8*	
lat. pronoti	" *12*		" *10,5*	
long. elytrorum	" *30*		" *25*	

Patria: Carin Chebà (900–1100 m.).

Hanitsch adds:

Hab: Java (Kirby). Burmah (Brunner; Kirby).

Panesthia wallacei Wood-Mason.

> *Panesthia wallacei* WOOD-MASON, Journ. Asiatic Soc. Bengal **45** [2] (1876) 189; KIRBY, Syn. Cat. Orth. 1 (1904) 204; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 152, pl. 2, fig. 12.

The original description is as follows:

Aterrima, nitidissima. Pronoto ut in *P. morione*, sed nitidiore et distinctius crebriusque punctato. Abdomine sparsim punctulato, punctis apicem versus sensim frequentioribus ac paullo majoribus; segmento ultimo marginibus integro angulisque posticis vix producto; lamina supraanali disco parce fulvo-pilosa, postice rotundata, tota integra, dentibus lateralibus nullis; lamina subgenitali confertim grosse punctata. Cercis tumidis, fulvo-pilosis. Tegminibus alisque pæne ut in *P. morione;* abdominis apicem longe superantibus; venarum omnium parte apicali perspicua utrinque pallida, subhyalina; illorum vena anali recta impressa hyalina. Femoribus anticis basin versus bidentatis. Long. corporis maris, ♂ 36½ mm., pronoti 9⅔, lat. pronoti lat. 14, long. tegminium 40, alarum 35, long. abdom. 18, abd. lat. (ad medium) 16.

No specimen of this species was found in the material studied in preparing the present paper. Hanitsch records a pair from Gunong Kledang, near Ipoh, Perak, which he took in March,

1898. These had three ventral spines on the anterior femora and showed the following measurements:

	mm.
Total length	42
Body, length	34
Pronotum, length	10
Pronotum, breadth	12.5
Tegmina, length	33

Habitat.—Sinkep Island, near Singapore (Wood-Mason). Gunong Kledang, Perak (Raffles Museum).

Genus **SALGANEA** Stål

Salganea STÅL, Oefv. Vet. Akad. Forh. **34** No. 10 (1877) 37; KIRBY, Syn. Cat. Orth. **1** (1904) 200; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 145.

The crenate lateral margins of the seventh segment of the abdomen and the presence of fully developed wings will separate this genus from the others of the subfamily Panesthinæ. The species of this genus, as well as others of the group, need thorough revision, but a lack of sufficient material makes this impossible at the present time. There are either some species almost inseparable on ordinary external characters or there is decided variation in the concealed genital organs; illustrative of this it may be stated that some males of what are considered *Salganea morio* Burmeister have four chitinous structures rendered clearly visible by removing the subgenital plate and the apically chitinous plate immediately dorsad of it, while in other specimens one or two of these characters are absent; all have a stout recurved hook curving under the edge of the genital cavity to the right and toward the terminus of a partly chitinous transverse ridge; on the left is a similar ridge which is usually without projecting structures; but in one specimen examined there was noted a short, curved, toothlike projection on the lower side, corresponding somewhat in position to that of the right-hand ridge, but much smaller; anterior to and near the right-hand hook mentioned above is a backwardly directed, rather slender, outwardly curved hook, present in three of the four males examined but abortive in the fourth; to the left of the last-mentioned hook and lying in the middle of the cavity near the posterior margin is a broadened but apically sharply pointed chitinous plate, always present but sometimes more deeply embedded in tissue than the other organs here mentioned, and apparently varying somewhat in shape, one presenting a single apical point while another is seemingly with two points. Whether the variations here noted are indicative of pleural species or not is difficult to judge at the present stage of our knowledge.

The species of this genus found in the regions covered by the present study may be separated as follows:

Key to species of Salganea Stål.

1. Anterior femora armed beneath with two or three stout spines, rarely with but one........ 2.
   Anterior femora unarmed beneath........ 3.
2. Size very large, length of female 60 to 70 millimeters or more; pronotum anteriorly with a pair of upwardly and backwardly directed hooked processes .... **S. papua Shelford.**
   Size smaller, rarely if ever as much as 60 millimeters in length; pronotum without processes as noted above........ **S. morio Burmeister.**
3. Size large, 40 millimeters or more in length; pronotal tubercles prominent .... **S. ternatensis Brunner.**
   Size smaller, rarely much over 30 millimeters in length........ 4.
4. Supra-anal plate apically distinctly crenate or denticulate........ 5.
   Supra-anal plate apically entire or gently undulate. **S. foveolata Saussure.**
5. Smaller, length little over 20 millimeters; habitat Java. **S. amboinica Brunner.** **S. rugulata Saussure.**
   Larger, length 30 millimeters, or slightly more; habitat Philippines. **S. humeralis Caudell.**

Salganea amboinica Brunner.

Salganea amboinica BRUNNER, Ann. Mus. Genova 33 (1893) 47; KIRBY, Syn. Cat. Orth. 1 (1904) 200; BRUNER, Univ. Studies, Lincoln, Nebr. 15 No. 2 (1915) 30.

Described by its author as follows:

Statura parva. Colore atro. Pronotum margine antico minime inciso, disco inaequali sed tuberculis elevatis nullis. Femora antica subtus inermia. Segmentum abdominale dorsale septimum margine laterali crenulato. Lamina supraanalis crenulata, disco toto impresso-puntato. ♂ ♀.

long. corporis	♂ *21 mm.*	♀ *21 mm.*
" *pronoti*	" *4,5*	" *4,5*
lat. pronoti	" *6,8*	" *6,8*
long. elytrorum	" *20*	" *18*

Patria: Amboina (coll. m.).

Four immature specimens of a yellowish color are referred here, all from Tjibodas, Mount Gede, Java, April 20, 1909

(*Bryant and Palmer*). This species seems very near *S. rugulata* Saussure and there is a probability that they may really be the same species. Some variation in the crenation of the posterior margin of the supra-anal plate indicates that this may be the case. In the nymphs examined the number of serrations varies from eight to ten in addition to the larger one on either side next the cerci. (Plate 1, fig. 8, shows a medium form.)

Salganea foveolata Saussure.

Salganea foveolata SAUSSURE, Rev. Suisse Zool. **3** (1895) 304; KIRBY, Syn. Cat. Orth. **1** (1904) 200.

Described as follows:

♀. Statura parva. Tota atra; clypeo et antennarum apice aurantia. Pronotum crassissime remote-punctatum, postice in medio tantum punctis paucis; area antica depressa, crasse granulosa, valde rugosa; margine antico medio leviter angulatim inciso; pone incisuram dentibus 2 retrodeflexis minimis instructo; tuberculis disci nullis. Meso-, metanotum et abdominis segmenta superne maxime polita, nitidissima; in medio impunctata, sed basi serie punctorum crassorum notata; utrinque punctis crassissimis remotis cribrosa; secundi segmenti margines laterales penicillo pilorum ruforum instructo. Segmenta 6–7 utrinque profundissime impressa, punctis impressis ingentibus, foveolatis; in medio polita, punctis nonnullis notata; 7° transverse convexo, margine depresso, punctis crassissimis signato. Dentes angulorum 6^{i} et 7^{i} apice obtuse; illi 7^{1} divergentes, longiores, crassi; margines laterales 7^{1} sublobati. Lamina supraanalis minus crasse punctata, margine subintegro, angulis lateralibus obtusis; ejus basis utrinque supra cercos incisa. Abdomen subtus crassiuscule punctatum. Elytra basi punctata, campo marginali crassissime punctato. Femora antica subtus inermia. Long. 26; pronot. 6; latit. 9 mm.—*Macassar*. (Mus. Genavense).

A single specimen found in the collections studied, a male from the Philippines, Sibuyan Island (*Baker*). It agrees very well with the above description and the wings are entire, not mutilated as they so often are in this group of roaches. The tegmina of this specimen measure 26 millimeters in length.

Salganea humeralis Caudell. Plate 1, fig. 9.

Salganea humeralis CAUDELL, Can. Ent. **38** (1906) 136; BRUNER, Univ. Studies, Lincoln, Nebr. **15** No. 2 (1915) 41.

Originally described as follows:

Size medium. General colour black, the under surface of the legs and of the body, except the last abdominal segment, or subgenital plate, and the mouth, except the mandibles, and also the vertex, reddish. The base of the elytra in the anal field is also tinted with reddish. Antennæ dark, hairy. Wings and elytra mostly missing. Anterior femora unarmed. Pronotum very slightly notched anteriorly, the disk with the usual irregular V-shaped depression and unequal elevations, but not distinctly tuberculate, the entire surface punctate. Base of the elytra smooth in the anal field, the costal field densely and coarsely punctate. Abdomen punctured, finer below along the median line, the segments transversely sulcate anteriorly above, more profoundly so towards the sides of the last three; seventh segment laterally irregularly crenulate, the latero-posterior angles divergent. Supra-anal plate rugulosely punctate, the posterior margin dully serrate; subgenital plate marked as the supra-anal plate, posteriorly emarginate.[5] Cerci short, triangular, hairy reddish in colour.

Length, 30 mm.; pronotum, 7,5 mm.; width, pronotum, 11 mm.; abdomen, 14 mm.

This species has not been reported from specimens other than the type material.

Salganea morio Burmeister.

Panesthia morio BURMEISTER, Handb. Ent. 2 (1838) 513; BRUNNER, Nouv. Syst. Blatt. (1865) 392.

Salganea morio KIRBY, Syn. Cat. Orth. 1 (1904) 200; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 145.

Panesthia regina SAUSSURE, Mem. Soc. Genève 17 (1864) 167, pl. 1, fig. 24.

Salganea regina KIRBY, Syn. Cat. Orth. 1 (1904) 200.

Burmeister's brief description, perhaps based on an immature specimen, is as follows:

Fusco-nigra, pronoti incisura acuta bituberculata; abdominis segmento antepenultimo margine dentato; elytris brevissimis trigonis, alis subnullis. Long. 1½″.—New Guinea, Australia.

Brunner's diagnosis of the adult female is as follows:

Aterrima. Pronoti incisurâ anticâ acutâ, subbituberculatâ, disco tuberculis quatuor plus minus distinctis. Elytrorum venis distinctiusculis. Abdominis segmento ultimo dorsali margine laterali dentato. Laminâ supraanali dentibus confertis. ♀.—Ceylon, Java, Amboina.

long.	fem.
corporis	33–52 mm.
pronoti	8–12
pron. transv.	12,5–18
elytrorum	37–?

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[5] This is an error, the subgenital plate being apically entire; the posterior edge is, however, laterally sulcate as is true of all species of these roaches.—A. N. C.

Hanitsch gives the following measurements of a large female in the Raffles Museum from Kota Tinggii, Johore:

	Female. mm.
Total length	55
Body, length	44
Pronotum, length	11
Pronotum, breadth	17
Tegmina, length	46

Fourteen specimens of this fine large roach were among the material studied. Java, Tjibodas, Mount Gede (*Barbour*), 1 male, 1 female; April 20, 1909 (*Bryant and Palmer*), 1 male, 2 females; Buitenzorg, April to December, 1896 (*D. G. Fairchild*), 1 male and 4 females, adults, and 4 female nymphs, 3 in what is probably the last stage and 1 about half grown, the last in very poor condition.

This species has a wide range, occurring in Australia, Java, Borneo, India, etc. All the material seen by me, except one male specimen, has the organs of flight more or less broken away; this fracture in every case commences on the anal margin of the tegmen at the posterior margin of the mesonotum and terminates at the posterior margin of the metanotum, the line of fracture extending in a slightly curved line which is so regular in its course as to cause the tegmina to appear naturally abbreviated; the posterior wings are generally broken off so as to be almost or quite concealed by the tegmina, showing that such alar mutilation is not, at least not altogether, a matter of accident.

Some specimens of these roaches have a number of the large round pits covering the dorsal surface of the terminal portion of the abdomen occupied by the immature stage of a mite, one specimen only in a pit. See notes under the genus on page 660 for a discussion of the concealed genital structures of the male.

Salganea papua Shelford.

Salganea papua SHELFORD, Mem. Soc. Ent. Belg. 15 (1908) 236.

No specimen of this gigantic roach has been seen by me nor has it been reported since its description. The original description is as follows:

♀. . Piceous, of large size. Pronotum anteriorly with a wide deep emargination, the angles of this upwardly and backwardly produced to form two hooked processes. Anterior part of pronotum depressed, granulate, with two curved oblique sulci, six small tubercles arranged semicircularly across the pronotum immediately behind the depressed area. Tegmina and wings considerably exceeding the apex of the abdomen, generally much mutilated or amputated. The first 5 abdominal tergites faintly punctate, the remainder deeply cribrate-punctate. Lateral margins of 7th tergite sinuate, dentate, posterior angles produced, an oblique depressed scar on either side of the disc of this tergite. Margin of supra-anal lamina finely and regularly dentate, a large blunt tooth on either side at the base. Cerci short, conical. Ventral surface more sparsely punctate than dorsal surface. Front femora with two spines on anterior margin beneath.

Total length 75 mm.; length of body 60–67 mill.; length of tegmina 63 mill.; pronotum 14 mill. × 24 mill.

Salganea rugulata Saussure.

> *Salganea rugulata* SAUSSURE, Rev. Suisse Zool. 3 (1895) 304; KIRBY, Syn. Cat. Orth. 1 (1904) 200; HANITSCH, Journ. Str. Br. Roy. Asiatic Soc. No. 69 (1915) 146.

♀. Gracilis, minuta, nigra; antennis, ore pronoto subtus, femoribus, ventre basi, rufo-fulvis. Pronotum depressiusculum, sparse haud crasse punctatum; area antica subtilius remote punctato; margine antico truncato, transverso, vel medio minute inciso; in hoc casu tuberculos minimos 2 præbente; tuberculis 2 centralibus disci minutis vel nullis. Meso. - metanotum et abdomen nitida, sparse punctata. Segmenta 1–5 frequenter margine (saltem in certo luce) angustissime rufolimbato. Segmenta 5–7 basi subconstricta, utrinque profunde impressa; 7^{n} postice depressum, subtilius densiusque punctatum, marginibus lateralibus rotundato-crenatis, spina apicali basi divergente. Lamina supraanalis densius haud crasse, vel confertim minute punctata punctis crassioribus intermixtis; margine postico valde denticulato, (denticulis confertis, trigonalibus, apice hebetatis), ac utrinque dente majore acuto. Cerci trigonales, rufidi. Subtus ultimum segmentum, saltem postice, crassiuscule densiuscule punctatum, margine apicali subtruncato, plicis marginis postici rugosis, etsi supra punctatis. Femora antica inermia. Tarsi graciles; metatarso postico tribus articulis sequentibus paulo longiore. — Long. 22; pronot. 4.9; latit. 7.2; elytr. 20; lat. abd. 9.8 mm.

Java (Amboina Br.).

Three adult and five immature specimens of this species present as follows:

Java, Tjibodas, Mount Gede (*Barbour*), 1 large black nymph; April 20, 1909 (*Bryant and Palmer*), 4 large black nymphs; Philippines, Mindanao, Mount Apo, June and July (*E. A. Mearns*), 3 adult females.

One only of the adults has complete wings, the others have the organs of flight partly broken away as previously noted under *S. morio*. In the nymphs the legs and clypeus and other portions of the mouth parts are yellowish, while in the adults the tibiæ and tarsi and most of the femora are black like the rest of the insect. As noted under *S. amboinica*, the present species may not be distinct from that slightly older species.

Salganea ternatensis Brunner.

Salganea ternatensis BRUNNER, Ann. Mus. Genova 33 (1893) 47; KIRBY, Syn. Cat. Orth. 1 (1904) 200.

? *Salganea dux* KIRBY, Ann. & Mag. Nat. Hist. VII 11 (1903) 408; Syn. Cat. Orth. 1 (1904) 200.

Brunner's description is as follows:

Pronotum utriusque sexus margine antico anguste emarginato, ad emarginationem utrinque tuberculato, disco tuberculis binis anticis altis, acuminatis, tuberculis posterioribus subobliteratis. Femora antica subtus inermia. Lamina supraanalis dense ferrugineo-hirsuta, margine postico subintegro. ♂ ♀.

long. corporis	♂ *43 mm.*	♀ *42 mm.*
" pronoti	*" 11*	*" 10*
lat. pronoti	*" 16,4*	*" 15,5*
long. elytrorum	*" ?*	*" 45*

Patria: Insula Ternate (coll. m.).

Salganea dux of Kirby is listed above as a synonym of *S. ternatensis* with a query, as no essential characters appear to separate them. Kirby's description is here quoted:

Long. corp. 43 millim.; lat. pron. 17 millim.; lat. abd. 22 millim.; exp. al. 117 millim.

Female.—Dark reddish chestnut above, shading into blackish at the extremities and on the lower part of the clypeus; under surface and legs of a lighter red; head dark reddish brown, shining; ocelli, labrum, and base of labium testaceous; labium otherwise light red; terminal plate of abdomen black above and below; pronotum with a broad upcurved ridge, from whence rises a semidetached frontal hood, deeply indented in the middle; pronotum thickly punctured, the central tubercles of the raised portion quite small, the outer ones rising into very large pyramidal but somewhat obtuse teeth; meso- and metanotum with deep carinæ, enclosing a triangle very broad at the base and obtusely pointed behind; the metanotum, and to a less extent the mesonotum, is obtusely and broadly angulated behind; the meso- and metanotum and the basal segments of the abdomen smooth and very sparingly punctured, the last three abdominal segments and the terminal plate increasingly thickly punctured both above and below; terminal plate, hinder half of the last segment of the abdomen, the extremity of the one preceding, and the cerci clothed with short testaceous hair; seventh segment with the sides distinctly dentated, and with a large terminal tooth; terminal plate rounded and entire, with only a strong tooth on each side just beyond the cerci. Front femora with only a terminal spine on the outer carina beneath. Tegmina and wings smoky brown, the extremities and the anal half of the wings smoky hyaline.

Hab. Obi (*Van Duivenborg*).

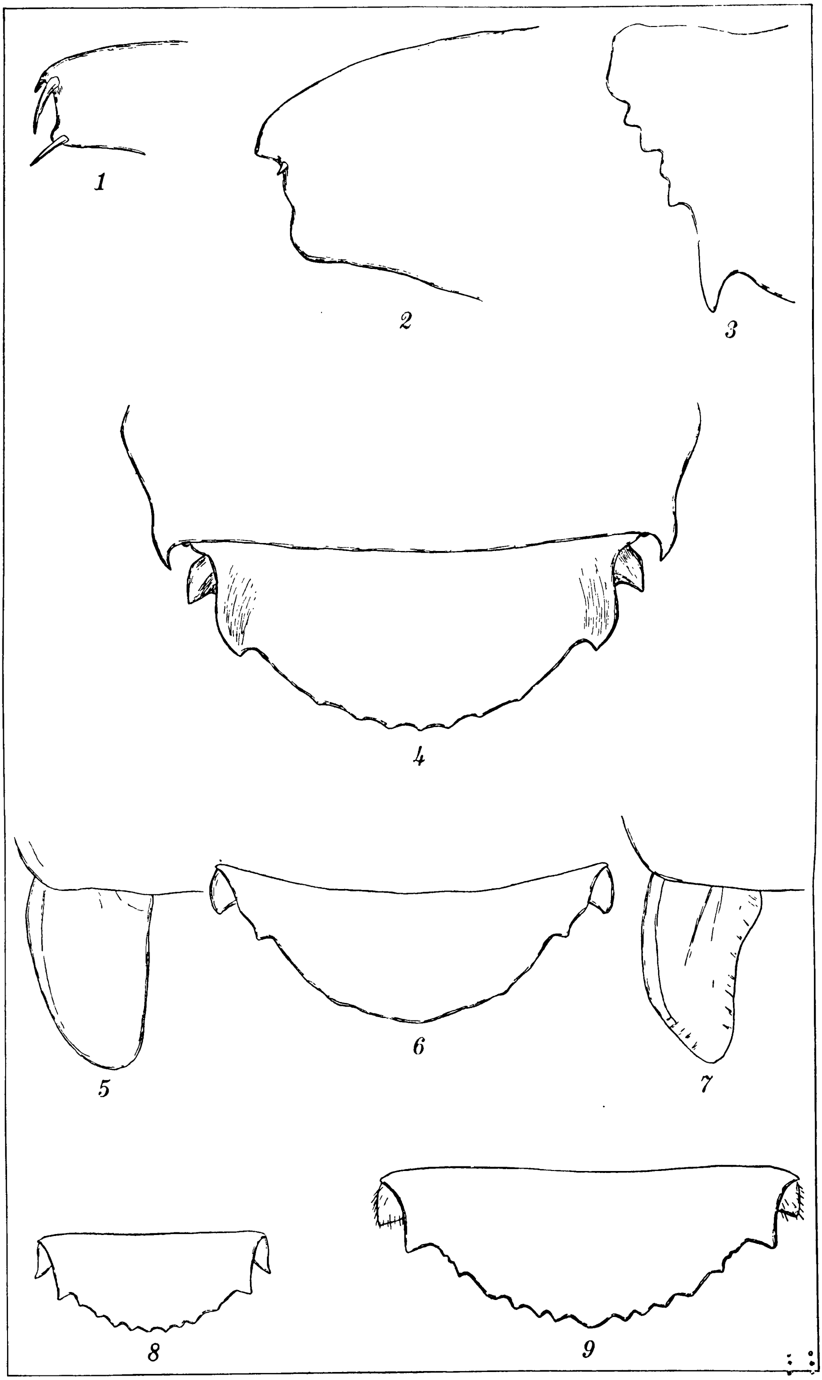
No specimens of *S. ternatensis* occurred in the collections studied nor have additional specimens been reported since the original descriptions of that species and its synonym *S. dux.*

ILLUSTRATION

PLATE 1. MALAYAN AND EAST INDIAN BLATTIDÆ

FIG. 1. *Gymnopeltis cryptospila* Walker. Ventro-apical margin of posterior femora.

2. *Panesthia æthiopis* Stoll. Ventro-apical margin of posterior femora.
3. *Salganea morio* Burmeister. Lateral margin of seventh abdominal segment.
4. *Panesthia bakeri* sp. nov. Lateral margin of seventh abdominal segment and entire supra-anal plate.
5. *Panesthia mearnsi* sp. nov. Left tegmen.
6. *Panesthia mearnsi* sp. nov. Supra-anal plate.
7. *Panesthia mearnsi* var. *uniformis* var. nov. Left tegmen.
8. *Salganea amboinica* Brunner. Supra-anal plate.
9. *Salganea humeralis* Caudell. Supra-anal plate.



1 2 3 4 5 6 7 8 9

PLATE 1.

LES ONTHOPHAGUS (COLEOPTERA, SCARABÆIDÆ) DES ILES PHILIPPINES

Par A. BOUCOMONT

Cosne (Nievri), France

Genus **ONTHOPHAGUS** Latreille

Tableau des especes.

1 (2). Premier article des antennes denté en scie; milieu de la tête avec une seule carène, obsolète chez les mâles. Base du vertex armé d'une lame surmontée d'une corne courte ♂, ou d'un tubercule transverse ♀. Thorax à ponctuation simple, nettement anguleux à la base. Tibias antérieurs ♂ prolongés en une griffe dépassant l'insertion des tarses. Noir, peu luisant (type). Brun bronzé, dessous testacé ainsi que les côtés du thorax, le sommet des élytres et le pygidium; parfois thorax testacé avec une grande tache discale brune, élytres testacés avec les interstries impairs rembrunis (var. *mindanaensis* Bouc.). Longueur, 12 à 14 millimètres .... **O. wallacei Har.**

2 (1). Premier article des antennes non denté en scie; tibias antérieurs non prolongés en griffe au sommet.

3 (4). Thorax, élytres et pygidium couverts de granules ovales serrés. Tête ogivale, ponctuée, épistome entier, front sans carène ♂; tête granulée, épistome incisé, front avec une carène fine ♀. Thorax généralement marqué de deux fovéoles lisses près des angles postérieurs. Dessus à pubescence blanchâtre; coloration variable, brun bronzé ou bleu d'acier, les élytres parfois testacés, en totalité ou en partie. Longueur, 4 à 9 millimètres. **O. rudis Sharp.**

4 (3). Thorax et élytres non granulées.

5 (8). Eperon des tibias postérieurs bifide. Tête grande, vertex prolongé en arrière en une lame coupante conchée sur le thorax.

6 (7). Carène frontale prolongée jusqu'aux bords latéraux de la tête, un petit tubercule ponctiforme derrière cette carène, vertex armé de deux cornes à section triangulaire, portant sur leur face antérieure une carène sinueuse prolongée jusqu'aux sutures génales. Sommet du thorax avec deux courtes carènes longitudinales. Elytres à interstries dorsaux lisses, les latéraux un peu ridés à ponctuation superficielle. Noir mat. Longueur, 12 millimètres .... **O. baeri Bouc.**

7 (6). Carène frontale réunie aux sutures génales qui sont en saillie, formant avec elles une ligne brisée, front sans tubercule, vertex armé de deux cornes plates, spatuliformes, très courtes, terminées par un petit tubercule sphéroïdal. Thorax à ponctuation râpeuse, muni en avant d'un lobe plat, plus ou moins nettement

bifide. Intervalles des élytres couverts de fins granules sétigères. Brun de poix plus ou moins bronzé, parfois verdâtre, thorax souvent bordé de testacé latéralement, élytres souvent roussâtres, plus rarement d'un noir bleuâtre. Longueur, 5.5 à 9 millimètres.. **O. praedatus Har.**

8 (5). Eperon des tibias postérieurs simple.

9 (26). Espèces entièrement glabres ou ayant seulement sur les intervalles latéraux des élytres une pubescence extrèmement courte et peu visible.[1]

10 (23). Base du thorax non rebordée.

11 (16). Base du thorax anguleuse, subdentée au milieu. Tête avec une carène frontale souvent obsolète, vertex muni d'une carène en arrière du bord postérieur des yeux. Thorax mutique à ponctuation simple, très fine, de coloration métallique rouge doré ou vert.

12 (13). Metasternum caréné et tectiforme en avant, couvert de granules. Epistome unidenté au sommet, carène frontale presque nulle, vertex légèrement relevé en buttoir à la base, ne formant pas une carène nette. Thorax sans impressions obliques à la base. Tête et thorax d'un rouge doré luisant, élytres noirs, mats. Longueur 7 à 11 millimètres........................ **O. semiaureus Lansb.**

13 (12). Metasternum non caréné en avant; taille plus petite. Epistome non denté, carène frontale bien marquée, vertex nettement caréné; base du thorax marquée de deux impressions obliques près des angles postérieurs.

14 (15). Prothorax rouge doré, élytres noirs, mats. Longueur 5 à 6.5 millimètres .... **O. semicupreus Har.**

15 (14). Prothorax vert plus ou moins cuivreux, élytres d'un vert foncé un peu terne, luisants; ponctuation des stries plus nettement transverse. Longueur, 4 à 6 millimètres.... **O. pilularius Lansb.**

16 (11). Base du thorax non dentée, dessus concolore.

17 (18). Dessus mat. Large, noir ou brun. Epistome trapezoïdal à bords fortement relevés, carène frontale continuée jusqu'aux bords latéraux de la tête, vertex armé d'une lame portant deux cornes larges et plates à la base. Thorax à base arrondie marqué d'une ponctuation très fine et serrée, brièvement rétus en avant, armé d'un très petit tubercule. Intervalles des élytres à ponctuation obsolète ou nulle. Pygidium superficiellement caréné dans sa longueur. Longueur, 8 à 11 millimètres.
O. dapitanensis Bouc.

18 (17). Dessus luisant.

19 (20). Stries des élytres très larges. Noir, tête et thorax bronzé ou verdâtre. Tête plane, inerme, finement ponctuée; thorax à ponctuation subombiliquée, sans sillon médian, bords latéraux rectilignes ou faiblement sinués en avant, fortement sinués en arrière. Stries des élytres marquées de points transverses, plus profonds le long du bord latéral, intervalles subconvexes, finement alutacés, à ponctuation finement râpeuse, peu serrée.

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[1] Voir plus loin *O. rasilis*, dont la pubescence est très courte.

Pygidium à très grosse ponctuation serrée. Prosternum excavé. ♂ Epistome anguleux à sommet réfléchi; thorax armé de deux tubercules près des angles postérieurs, déterminant deux plans inclinés vers les angles antérieurs. ♀ Epistome arrondi, thorax simple. Longueur, 4.5 á 5 millimètres.... **O. bangueyensis Bouc.**

20 (19). Stries des élytres étroites.

21 (22). Taille petite; noir ou brun. Vertex inerme ♂, ou avec une carène obsolète ♀; carène frontale courbe reliée aux sutures génales. Thorax très convexe, rétréci à la base, bords latéraux presque rectilignes en avant, à peine sinués en arrière, surface assez densément et fortement ponctuée. Stries des élytres enfoncées, fortement ponctuées, toutes libres au sommet, intervalles convexes à ponctuation très fine, espacée. Ponctuation du pygidium assez grosse avec des poils courts, dressés. Longueur, 4 à 4.5 millimètres.. **O. inermivertex Bouc.**

22 (21). Taille moyenne; vertex armé d'une corne, d'une lame ou d'une carène très nette. Noir, luisant, avec un très faible reflet bronzé sur le thorax. Tête finement ponctuée; thorax a ponctuation fine peu serrée; intervalles des élytres plats, à ponctuation fine sur les latéraux, les dorsaux lisses. ♂ Epistome anguleux à sommet arrondi, portant en son milieu un appendice en forme de T; vertex armé d'une corne fourchue, plate, en forme de Y; front sans carène; thorax gibbeux et rétus en avant. ♂ minor (var. *sus* Bouc.). Epistome tronqué et relevé en groin, vertex armé d'une lame bifurquée en deux cornes courtes, plates. ♀ Epistome trapézoïdal, front gibbeux avec une carène courte, atténuée à ses extrémités; vertex muni d'une forte carène située au niveau du bord postérieur des yeux, occupant la moitié de leur intervalle; thorax non gibbeux mais avec une trace de lobe au sommet. Longueur, 8 à 9 millimètres .... **O. galeatus Bouc.**

23 (10). Base du thorax rebordée. Epèces noires.

24 (25). Peu luisant; thorax à ponctuation homogène, écartée, angles arrondis au côté externe; septième strie des élytres sinueuse; ponctuation du pygidium à peine plus grosse que celle du thorax. ♂ Tête grande, trapézoïdale, épistome tronqué, front muni d'une carène reliée aux sutures génales, vertex armé d'une forte lame couchée sur le thorax, surmontée de deux cornes hélicoïdades courtes, convergeant au sommet; thorax un peu rétus en avant, sans arète ni carène. ♀ Front avec deux carènes en courbes concentriques, l'antérieure reliée aux sutures génales; vertex muni d'une carène élevée à sommet sinué. Longueur, 6 à 9 millimètres.. **O. armatus Blanch.**

25 (24). Trés luisant; thorax á ponctuation fine et écartée sur le disque, plus grosse et plus serrée vers les angles antérieurs, très serrée au milieu du sommet; angles antérieurs acuminés, nettement sinués au côté externe; septième strie des élytres courbe; ponctuation du pygidium beaucoup plus grosse que celle du thorax. Noir avec un léger reflet métallique sur le thorax. Epistome anguleux à sommet relevé, tête inerme sauf une très courte et

faible carène au niveau du bord postérieur des yeux; ponctuation fine et serrée, celle de l'épistome ridée. Thorax à deux plans inclinés vers les angles antérieurs, limités en arrière par un tubercule dentiforme situé vers les angles postérieurs; ces plans inclinés sont mats; base finement rebordée et bordée d'une ligne de points. Elytres à stries étroites, ponctuées, intervalles convexes à ponctuation très fine et écartée, obsolète sur les intervalles dorsaux. Metasternum presque lisse au milieu, marqué a l'arrière d'un sillon fovéiforme ♂. Forme générale d'*O. bakeri*. Longueur, 6.5 millimètres.
O. tagal sp. nov.

26 (9). Espèces à pubescence visible sur le thorax, au moins sur les côtes, et sur les élytres, au moins sur les côtés et le sommet.

27 (30). Espèces à longue villosité jaune. Carène frontale longue; thorax non rebordé a la base, ses angles antérieurs à côté externe rectiligne.

28 (29). Epistome parabolique, vertex muni d'une carène courte. Tête et thorax bronzès verdâtres, èlytres noirs à tache humérale jaunâtre. Thorax fortement ponctué, avec une ligne longitudinale élevée, lisse, non sinué au côté externe des angles postérieurs; intervalles des élytres subconvexes, ridés, ponctués. Longueur, 4 millimètres................................ **O. hirsutulus** Lansb.

29 (28). Epistome arrondi, subtronqué en avant, vertex armé de deux tubercules. Tête et thorax bronzés, parfois testacés; élytres noirs ou bruns avec des taches jaunes ou rougeâtres variables: généralement deux taches basales, une latérale et une apicale, parfois les taches basales sont réunies et envahissent toute la base sauf l'interstrie sutural. Carène frontale très longue, réunie aux sutures génales qui sont très courtes. Thorax convexe densément et assez fortement ponctué, nettement sinué au côté externe des angles postérieurs. Intervalles des élytres subconvexes à ponctuation râpeuse vaguement bisériée. Longueur, 4 à 5 millimètres................................ **O. aereopictus** Bouc.

30 (27). Espèces non villeuses.

31 (58). Angles postérieurs du thorax nettement sinués au côté externe.

32 (37). Base du thorax nettement rebordée.

33 (34). Tête presque inerme, sans carène frontale, vertex muni de deux tubercules obsolètes situés un peu en arrière du bord antérieur des yeux. Brun concolore, cuisses plus ou moins rougeâtres; pubescence longue, jaune, écartée, sur les côtés du thorax et des élytres. Tête en ogive tronquée, densément ponctuée, yeux grands; thorax longuement déclive en avant, la déclivité limitée en arrière par une gibbosité médiane, angles antérieurs à côté externe rectiligne, angles postérieurs sinués, surface couverte d'une ponctuation fine, écartée, plus forte et plus écartée sur les côtés, une ligne régulière de gros points le long du rebord latéral, continuée le long de la base. Stries des elytres étroites, marquées de points transverses entamant les inter-

valles, toutes libres au sommet, la septième à peine sinueuse; intervalles dorsaux à ponctuation très fine et très écartée, l'intervalle latéral à points râpeux sétigères bien plus gros et plus serrés. Pygidium à gros points enfoncés peu serrés. Tibias antérieurs grêles terminés par un pinceau de polis dorés. Fémurs antérieurs munis au bord antérieur d'une carène bordée de gros points piliféres. Longueur, 7 millimètres.
O. cuneus sp. nov.

34 (33). Tête munie de cornes ou de carènes, jamais inerme; thorax à ponctuation serrée, non déclive en avant.

35 (36). Jaune citron, avec les rebords, les sutures, la base des élytres, les bords des cotyles d'un vert métallique, metasternum marqué de deux bandes longitudinales vertes, pygidium avec deux points bruns. Dessus à très courte et très fine pubescence jaune, dressée; entièrement et assez finement ponctué. ♂ Epistome anguleux, réfléchi, carène frontale obsolète, vertex armé, derrière les yeux, de deux cornes courtes et plates; thorax muni d'un lobe bifide obsolète, en avant. ♀ Tête à deux faibles carènes, celle du front rectiligne, non reliée aux sutures génales, celle du vertex sinuée et occupant la moitié de l'intervalle des yeux. Longueur, 5.5 à 8 millimètres............ **O. citreum Bouc.**

36 (35). Noir légèrement bronzé, élytres marquées d'une tache humérale et de quelques taches apicales rougeâtres peu apparentes; ponctuation plus fine et bien moins serrée. ♂ Epistome arrondi à sommet réfléchi, carène frontale nette, vertex armé, entre les yeux, de deux cornes courtes, droites, cylindriques; thorax rétus en avant. ♀ Carène frontale plus forte, carène du vertex haute et longue, occupant les deux tiers de l'intervalle des yeux; thorax muni d'un lobe anguleux obsolète. Longueur, 5 à 7 millimètres.. **O. gestroi Har.**

37 (32). Base du thorax non rebordée, sauf parfois au milieu.

38 (39). Pygidium non rebordé à la base; thorax renflé vers les angles postérieurs, couvert d'une ponctuation enfoncée. Noir, plus ou moins bronzé à pubescence jaune assez longue. ♂ Vertex armé de deux cornes courtes, arquées, reliées par une lame surélevée au milieu. ♀ Vertex avec une carène tridentée; thorax muni d'une carène transverse interrompue au milieu. Longueur, 7 à 11 millimètres............................ **O. orientalis Har.**

39 (38). Pygidium rebordé à la base; thorax non renflé vers les angles postérieurs.

40 (43). Thorax armé de tubercules près du bord antérieur; élytres jaunes tachés de noir ou noirs tachés de jaune.

41 (42). Thorax avec trois tubercules. Bronzé cuivreux, élytres jaunes avec une fascie noire, l'intervalle sutural et une tache à la base du 5° intervalle noirs. ♂ Vertex armé d'une lame surmontée d'une petite corne. ♀ Vertex avec une caréne longue. Longueur, 5 à 8 millimètres............................ **O. trituber Wied.**

42 (41). Thorax avec deux tubercles. Bleu métallique sombre à pubescence jaune, courte, dressée; élytres marqués de taches jaunes: une humérale et deux autres confluentes sur les 2° et 4° intervalles. Epistome brièvement bidenté, carène frontale bidentée, vertex armé de deux dents aigües; thorax armé de deux dents en avant, angles antérieurs légèrement sinués au côté externe. Longueur, 5 millimètres[2]............................ **O. sexdentatus** Bouc.

43 (40). Thorax inerme ou avec des tubercles placés loin du bord antérieur, ou encore chez les ♀ avec de petits tubercules transverses obsolètes.

44 (47). Elytres marquées de taches jaunes sur toute leur surface. ♂ Tête ogivale à sommet relevé sans carène frontale; angles antérieurs du thorax aigus.

45 (46). Mat, brun clair faiblement bronzé, pubescence courte; élytres marqués de nombreuses petites taches quadrangulaires flaves, interstries à ponctuation granuleuse serrée; pygidium plat. ♂ Tête très densément ponctuée, un petit tubercule entre les yeux; thorax à deux plans inclinés vers les angles antérieurs; tibias antérieurs à éperon très long. ♀ Carène frontale rectiligne, vertex avec deux tubercules transverses; thorax simple. Longueur, 7 millimètres.................................. **O. calcaratus** Bouc.

46 (45). Luisant, thorax vert métallique ou bronzé, élytres noirs marqués de quelques grandes taches rondes jaunes, ponctuation des intervalles faiblement râpeuse, le deuxième intervalle presque lisse; pubescence du thorax longue; pygidium convexe. ♂ Tête lisse sauf quelques points près des yeux; thorax conique avec un tubercule médian, angles antérieurs fortement sinués au côté externe. ♀ Tête avec deux carènes rectilignes très saillantes, atténuées au milieu, celle du vertex plus courte; thorax muni, en avant, d'un faible tubercule comprimé, angles antérieurs non sinués. Longueur, 5.5 à 8 millimètres. **O. pastillatus** Bouc.

47 (44). Elytres sans taches discales, soit concolores, soit avec des taches basales et apicales.

48 (49). Angles postérieurs du thorax avec un espace lisse. Coloration variable: tête et thorax brun bronzé, rarement testacé, élytres d'un brun plus ou moins foncé avec des taches basales flaves (la race de Palawan est d'un rouge cuivreux avec les élytres noirs sans taches). ♂ Tête armée sur le vertex d'une lame terminée en pointe, carène frontale nulle ou obsolète. ♂ Tête avec deux carènes, thorax avec deux petits tubercules transverses en avant. Longueur, 7 à 9 millimètres.
O. javanus Lansb.

49 (48). Angles postérieurs du thorax sans espace lisse.

50 (51). Ponctuation des intervalles dorsaux des élytres granuleuse. Peu luisant, noir, tête et thorax légèrement verdâtres, bords de l'abdomen plus ou moins rougeâtres; dessus densément

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[2] Mr. G. J. Arrow m'a informé que ma description se rapporte à la ♀ d'une espece dont le ♂ est armé à la base du thorax d'une corne longue et grêle.

et finement ponctué avec une pubescence assez courte, jaunâtre. Epistome en ogive obtuse, ses bords latéraux non sinués, carène frontale ♂ nulle, ♀ presque rectiligne et continuée jusqu'aux bords latéraux de la tête; carène du vertex rectiligne, placée entre les milieux des yeux dont elle occupe plus de la moitié de l'intervalle. Thorax ♂ armé de deux petits tubercules ponctiformes, en avant. Très voisin de *cervicapra* Bouc. dont il diffère par la pubescence, par la ponctuation granuleuse des élytres et par l'armature de la tête. La femelle pourrait être confondue avec celle d'*O. babirussa* var. *obscurior*, elle s'en distingue par l'absence de toute tache jaune, le thorax sans tubercule net et par l'armature de la tête. Longueur, 6 à 7 millimètres.................... **O. eschscholtzi sp. nov.**

51 (50). Ponctuation des intervalles des élytres simple ou parfois finement râpeuse.

52 (53). Carène du vertex reliée aux sutures génales. Petit, ovale, convexe, métallique luisant, thorax bronzé ou vert, élytres verdâtres plus ou moins foncés. Thorax très convexe, densément ponctué. Elytres à stries fines, intervalles plats ridés et à ponctuation bisériée. Longueur, 3 millimètres.......... **O. lilliputanus Lansb.**

53 (52). Sutures génales parfois reliée à la carène frontale, mais jamais à celle du vertex.

54 (55). Dessus mat. Testace ou brun clair, tête brune, thorax avec une grande tache discale brune plus ou moins étendue, stries des élytres généralement rembrunies. Parfois (var. *obscurior* Bouc.) noir avec les bords latéraux du thorax étroitement tachés de jaune, le disque verdâtre. Dessus à ponctuation très fine, carènes du prosternum écourtées et presque droites. ♂ Vertex armé de deux cornes plates. ♀ Tête avec deux carènes, thorax muni d'un bourrelet transverse en avant. Longueur, 6 à 8 millimètres .... **O. babirussa Esch.**

55 (54). Dessus luisant, front muni d'une gibbosité médiane, carènes du prosternum longues et sinueuses.

56 (57). Dessus à ponctuation assez forte, plus enfoncée et plus évasée, pubescence latérale plus étendue. Couleur variable: noir avec le thorax légèrement bronzé, élytres souvent roux. ♂ Tête anguleuse à sommet fortement relevé, sans carène, thorax à deux plans inclinés vers les angles antérieurs. ♀ Tête à deux carènes, l'antérieure atténuée à ses extrémités, accolée à la gibbosité, celle du vertex placée au niveau du bord postérieur des yeux. Longueur, 7 à 8 millimètres............ **O. bakeri Bouc.**

57 (56). Dessus à ponctuation fine, moins enfoncée et plus nette; pubescence latérale du thorax rare, celle des intervalles dorsaux des élytres limitée au sommet; gibbosité frontale plus faible. Noir, très luisant, dessous parfois brun clair. Elytres à stries peu marquées, la septième très sinueuse, intervalles plats à ponctuation obsolète, sauf sur l'intervalle latéral oú elle est très nette et très dense. Pygidium scutiforme à ponctuation assez grosse et serrée. Métasternum finement sillonné et éparsement pointillé. ♂ Tête parabolique, les joues à peine saillantes,

continuant la courbe de l'épistome; épistome à sommet perpendiculairement relevé en une lame anguleuse portant en avant, à sa base, une ligne transverse de points; toute la tête densément couverte d'une ponctuation assez fine, enfoncée, sans carène mais la base du vertex est relevée en buttoir. Thorax marqué, de chaque côté du milieu, d'une excavation longitudinale à fond presque lisse, déterminant une gibbosité médiane de forme subhexagonale dont les angles latéraux sont saillants en une grosse dent dirigée en dehors; au côté externe de l'excavation se trouve une petite dent dirigée vers la première. ♀ Tete suborbiculaire à sommet sinué, carène frontale fine, ne joignant pas les sutures génales, carène du vertex obsolète; ressemble beaucoup à *bakeri* ♀, en diffère par la courbe des bords latéraux de la tête sans sinuosité et par la ponctuation. Longueur, 6.5 à 7.5 millimètres........................ **O. sibuyanus** Bouc.

58 (31). Angles postérieurs du thorax non ou à peine sinués au côté externe.

59 (60). Epistome non incisé ni bidenté. Tête complètement inerme, finement pointillée. Thorax fortement rétus avec un lobe trapézoïdal échancré au sommet. Très luisant, noir, légèrement bronzé avec des taches diffuses rougeâtres aux côtés du thorax et autour des élytres; dessus densément et finement ponctué avec une pubescence extrêmement courte, a peine visible. Longueur, 7 millimètres.. **O. rasilis** Bouc.

60 (59). Epistome incisé ou bidenté.

61 (64). Thorax à ponctuation simple; dessus brun, mat.

62 (63). Thorax à ponctuation serrée. Brun clair avec des taches jaunes variables, généralement sur les côtés du thorax et le milieu de la base, à la base et au sommet des élytres, pygidium jaune avec deux points bruns, pattes jaunes. Elytres à ponctuation granuleuse serrée. ♂ Vertex armé d'une dent, front inerme, tibias antérieurs grêles, longs et courbés. ♀ Vertex avec un tubercule transverse obsolète, front avec deux carènes. Longueur, 5 à 6 millimètres.. **O. philippinensis** Bouc.

63 (62). Thorax à ponctuation écartée. Elytres à trois taches fauves latérales, et une apicale enfermant un point foncé, pygidium jaune marqué souvent d'un point brun, pattes brunes. Intervalles des élytres à ponctuation finement granuleuse bisériée. Tête ayant seulement une courte carinule oblique près de chaque oeil. Longueur, 4 millimètres........................ **O. terminatus** Esch.

64 (61). Thorax à ponctuation ombiliquée, laissant le long de la base une étroite bande lisse, avec une ligne marginale de points; élytres à pubescence courte, sériée, de couleur claire, toutes les stries libre au sommet, la 7° sinueuse. Epistome ♂ acuminé ou appendiculé, ♀ bidenté.

65 (66). Côtés de la tête nettement sinués à la jonction de l'épistome et des joues, surtout ♂. Thorax convexe à ponctuation ombiliquée assez grosse, profonde et homogène. Elytres à stries larges marquées de points transverses entamant les intervalles, ponctuation des intervalles peu nette, rugueuse. Pygidium à

grosse ponctuation ombiliquée, serrée et à pubescence dressée très courte. Tarses postérieurs courts et grêles. ♂ Epistome continué à son bord antérieur en un appendice recourbé en arrière, fortement élargi au sommet et bifurqué, plus long et plus grêle que chez *O. batillifer* Har., tête lisse et concave derrière l'appendice, front un peu gibbeux, joues à bords relevés. Thorax muni en avant d'un tubercule conique. ♀ Epistome échancré et bidenté, front avec une petite élévation transverse, obsolète, vertex muni d'une carinule courte, placée entre les milieux des yeux et dont les extrémités sont recourbées en avant. Thorax inerme. Brun de poix, la tête, les bords antérieur et latéraux du thorax, la base et le sommet des élytres souvent un peu rougeâtres, pygidium, bords de l'abdomen généralement rougeâtres. Longueur, 4 à 5 millimètres. **O. sceptrifer sp. nov.**

66 (65). Côtés de la tête non sinués, front inerme; ponctuation du thorax plus fine et plus serrée; vertex ♀ avec une petite ligne lisse, plus ou moins saillante, dont les extrémités sont recourbées en avant, chez les ♂, cette carène est nulle ou réduite à deux lignes obliques à peine sensibles, près des yeux, ♀ tête densément ponctuée.

67 (68). Intervalles des élytres à points simples, stries faiblement ponctuées. ♂ Epistome prolongé en un appendice en forme de T recourbe en arrière; thorax armé de deux petits tubercles très rapprochés l'un de l'autre, près du bord antérieur. Brun, élytres d'un testacé rougeâtre. Longueur, 4 millimètres. **O. lunulifer Bouc.**

68 (67). Intervalles des élytres à ponctuation râpeuse ou granuleuse, stries fortement ponctuées, surtout les latérales. ♂ Epistome acuminé et relevé sans appendice[8], thorax déclive en avant. Coloration brune avec des taches jaunes très variables, soit presque entièrement brune, soit presqu' entièrement testacée avec les stries brunes. Diffèrent d'*O. deflexicollis* Lansb. par la taille plus petite, les côtés de la tête non anguleux, la ponctuation ombiliquée du thorax, les stries des élytres ponctuées et les intervalles à points granuleux ou râpeux.

69 (70). Stries dorsales des élytres nettement marquées de points assez grands, ronds, enfoncés, intervalles à ponctuation plus nettement granuleuse; pubescence dressée plus longue. ♂ Thorax armé d'un tubercule dentiforme, conique, au quart postérieur; le devant déclive. Longueur, 3.2 millimètres...... **O. zebu Bouc.**

70 (69). Un peu plus grand; stries dorsales à ponctuation moins enfoncée, ponctuation des intervalles râpeuse; pubescence dressée très courte. ♂ Thorax armé de deux tubercules latéraux, peu saillants, reliés par une arète courbe limitant la partie déclive qui occupe les $\frac{2}{3}$ antérieurs, sans tubercule médian. Longueur, 3.2 à 3.8 millimètres.. **O. unidens Bouc.**

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[8] Il est possible que les mâles bien développés aient un appendice, comme *O. batillifer* Har., mais je n'en ai pas vu.

CATALOGUE

Genus ONTHOPHAGUS Latreille

aereopictus BOUCOMONT, Ann. Soc. Ent. France **83** (1914) 326. Décrit des Iles Philippines.

LUZON, Los Baños (*Baker*); Mount Maquiling (*Baker*); Mount Banahao (*Baker*). BORNEO, Sandakan (*Baker*); BANGUEY; Singapore (*Baker*).

armatus E. BLANCHARD, Voyage au Pôle Sud (1853) 98, pl. 7, figs. 9, 10; BOUC., op. cit. 305; BOUC. in Vitalis, Faune Indochine 4 (1921) 29, 52. Décrit de Bornéo, cité de l'Archipel Malais et d'Asie Orientale.

luzonicus LANSBERGE, Notes Leyden Mus. **5** (1883) 44.

LUZON, Manille; Los Baños (*Baker*); Mount Maquiling (*Baker*).

babirussa ESCHSCHOLTZ, Entomogr. **1** (1822) 33. Décrit de Luzon. BOUC., op. cit. 294, cité de l'Archipel.

LUZON, Mount Banahao (*Baker*); Mount Maquiling (*Baker*); Baguio, Benguet (*Baker*); MINDANAO, Iligan (*Baker*); Surigao (*Baker*); Cagayan (*Baker*); BASILAN (*Baker*).

var. obscurior BOUC., loc. cit. Décrit de Bornéo.

LUZON, Mount Maquiling (*Baker*).

baëri BOUC., Ann. Soc. Ent. Fr. **83** (1914) 307. Décrit de Davao.

MINDANAO, Davao; Iligan (*Baker*).

bakeri BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 312. Décrit de Luzon.

LUZON, Los Baños (*Baker*); Mount Banahao (*Baker*); Mount Maquiling (*Baker*).

bangueyensis BOUC., Ann. Soc. Ent. Fr. **83** (1914) 323, ♂ minor et ♀, décrit de I'le Banguey. ♂ major, décrit ci-dessus.

PALAWAN, Binaluan (*G. Boettcher*).

calcaratus BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 316, ♂; Bull. Soc. Ent. Fr. (1921) 92, ♀.

MINDANAO, Dapitan (*Baker*).

citreum BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 312.

LUZON, Mount Maquiling (*Baker*); Mount Banahao (*Baker*).

cuneus sp. nov.

PALAWAN, Binaluan (*G. Boettcher* 1913).

dapitanensis BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 318.

MINDANAO, Dapitan (*Baker*).

eschscholtzi sp. nov.

PALAWAN, Binaluan (*G. Boettcher*).

galeatus BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 315, ♂; Bull. Soc. Ent. Fr. (1921) 92, ♀:

var. *sus* BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 317; Bull. Soc. Ent. Fr. (1921) 92.

MINDANAO, Iligan (*Baker*); Dapitan (*Baker*); Kolambugan (*Baker*); Surigao (*Baker*); Tangkulan, Bukidnon (*Baker*); BASILAN (*Baker*).

gestroi HAROLD, Ann. Mus. Civ. Genova **10** (1877) 59; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 304, 305. Décrit des Célebes et de Sumatra, cité de Saleyer, Sumbawa, et Tenimber.

LUZON, Los Baños (*Baker*); Mount Maquiling; MINDANAO, Surigao (*Baker*); Sibuyan. BORNEO, Sandakan (*Baker*).

hirsutulus LANSBERGE, Notes Leyden Mus. **5** (1883) 67; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 324, 325. Décrit de Java, cité de Sumatra.

MINDANAO, Surigao (*Baker*).

inermivertex BOUC., Bull. Soc. Ent. Fr. (1921) 90.

MINDANAO, Iligan (*Baker*); Dapitan (*Baker*).

javanus LANSBERGE, op. cit. 55; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 287, 291. Décrit de Java, cité de Sumatra.

var. à élytres noirs, thorax rouge cuivreux.

PALAWAN, Binaluan (*Boettcher*). BORNÉO, Pontianak (*coll. R. Oberthür*); Doesonlanden (ex coll. N. van de Poll).

lilliputanus LANSBERGE, op. cit. 69; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 280, 284. Décrit de Java, cité de Sumatra et Bornéo. Une variété se rencontre dans l'Inde.

LUZON, Los Baños (*Baker*); Mount Banahao (*Baker*); MINDANAO, Butuan (*Baker*).

lunulifer BOUC., Ann. Soc. Ent. Fr. **83** (1914) 309.

LUZON, Los Baños (*Baker*) coll. J. Gillet; Mount Maquiling (*Baker*); Mount Banahao (*Baker*).

orientalis HAROLD, Coleopt. Hefte **4** (1868) 83; SHARP, Col. Hefte **14** (1875) 56; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 299; BOUC., in Vitalis, Faune Indoch. **4** (1921) 34, 54. Décrit de Hong Kong et du Bengale, cité de l'Archipel Malais et de l'Asie Orientale.

PALAWAN (ex coll. van de Poll).

pastillatus BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 318, ♂; Bull. Soc. Ent. Fr. (1921) 92, ♀

MINDANAO, Iligan (*Baker*). BORNÉO, Sandakan (*Baker*); Martapura (*Doherty* 1891); Mount Matang, W. Sarawak (*G. E. Bryant*) coll. du British Museum.

philippinensis BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 313.

LUZON, Mount Banahao (*Baker*); MINDANAO, Iligan (*Baker*); SIBUYAN.

pilularius LANSBERGE, op. cit. 71; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 276, 277. Décrit de Java, cité de Sumatra et Bornéo.

PALAWAN (ex coll. van de Poll.)

praedatus HAROLD, Berlin. Ent. Zeitschr. **6** (1862) 403 nomen nudum; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 307.

verticalis BOHEMAN, Freg. Eugen. Resa (1858) 44. Décrit de Manille.

LUZON, Los Baños (*Baker*); Mount Banahao (*Baker*); Mount Maquiling (*Baker*); MINDANAO, Butuan (*Baker*).

rasilis BOUC., Bull. Soc. Ent. Fr. (1921) 91.
MINDANAO, Iligan (*Baker*).

rudis SHARP, Col. Hefte **14** (1875) 58; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 271; BOUC., in Vitalis, Faune Indoch. **4** (1921) 35, 41. Décrit du Siam, cité de Java, Bornéo, Sumatra, Nias, Lombock, Malacca, Darjiling, et d'Indochine.
asper SHARP, op. cit. 59 (Célebes).
foveolatus HAROLD, Ann. Mus. Civ. Genova **10** (1877) 68. Bornéo.
LUZON, Los Baños (*Baker*); Mount Maquiling (*Baker*); MINDANAO, Surigao (*Baker*); Davao (*Baker*); Dapitan (*Baker*); Kolambugan (*Baker*); PALAWAN, Bacuit (*Boettcher*).

sceptrifer sp. nov.
PALAWAN, Bacuit (*Boettcher*).

semiaureus LANSBERGE, Notes Leyden Mus. **5** (1883) 75; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 275. Décrit de Java et Sumatra, cité de Bornéo et Célébes.
PALAWAN (ex coll. van de Poll).

semicupreus HAROLD, Ann. Mus. Civ. Genova **10** (1877) 81; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 277. Décrit de Bornéo, cité de Java et Malacca.
PALAWAN, Bacuit (*Boettcher*).

sexdentatus BOUC., Ann. Soc. Ent. Fr. **88** 1919 (1920) 319.
LUZON, Mount Banahao (*Baker*).

sibuyanus sp. nov.
SIBUYAN (*Baker*).

tagal sp. nov.
SIBUYAN (*Baker*).

terminatus ESCHSCHOLTZ, Entomogr. (1822) 32; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 318, 322. Décrit de Luzon.
LUZON, Mount Maquiling (*Baker*).

trituber WIEDEMANN, Zool. Mag. 2, **1** (1823) 17; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 286, 289; BOUC., in Vitalis, Faune Indoch. **4** (1921) 37, 50. Décrit de Java, cité de Sumatra, Amboine, Tonkin, et Formose.
suturalis WHITE, Ann. Nat. Hist. I **13-14** (1844) 424. Décrit de Hongkong.
La présence de cette espèce aux iles Philippines est douteuse; j'ai cependant rencontré dans une collection qui m'a été communiquée, quelques exemplaires portant des étiquettes de cette provenance.

unidens BOUC., Ann. Soc. Ent. Fr. **83** (1914) 308, note I.
LUZON, Los Baños (*Baker*); Mount Maquiling (*Baker*); Mount Banahao (*Baker*).

wallacei HAROLD, Col. Hefte **8** (1871) 114; BOUC., Ann. Soc. Ent. Fr. **83** (1914) 266. Décrit des Célèbes, cité des iles Aru, Amboine, Saleyer, Ternate, et de Java.
ovilis SHARP, Col. Hefte **14** (1875) 59.
simulans SHARP, op. cit. 60.
var. *fraternus* LANSBERGE, Notes Leyden Mus. **5** (1883) 42.
var. *mindanaensis* BOUC., Ann. Soc. Ent. Fr. **83** (1914) 268.
MINDANAO, Dapitan (*Baker*); Davao; MINDORO.

zebu BOUC., Bull. Soc. Ent. Fr. (1921) 89.
MINDANAO, Kolambugan (*Baker*); Dapitan (*Baker*); Bukidnon, Tangkulan (*Baker*).

DISTRIBUTION OF TRUE FRESH-WATER FISHES IN THE PHILIPPINES, II

THE PHILIPPINE LABYRINTHICI, CLARIIDÆ, AND SILURIDÆ

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TWO PLATES

This paper completes a survey of the strictly fresh-water Philippine fishes, within the limits set in the introduction to Part I.[1] The remaining species are few; namely, dalag, climbing perch, two catfishes of general or wide distribution, and one, highly localized osphronemid. Any further discussion of the fishes found in the rivers and lakes of the Philippines, unless limited to single species or genera, would necessitate a consideration of forms dwelling largely in brackish or salt water and is therefore omitted. One order, including three families, and two families belonging to the order of catfishes, with two new genera and two new species, are here presented.

In this paper the length recorded does not include the caudal fin, except where so stated.

Order LABYRINTHICI

An assemblage of fishes, either perchlike with oblong and compressed, or elongate and more or less cylindrical body, characterized especially by the presence of a large cavity in the head above the gills. The latter is a peculiar modification of the upper elements of one of the pairs of gill-bearing arches. Instead of the branchihyals being straight and solid, as in most fishes, they are excessively developed and in all except the Ophicephalidæ are provided with several thin plates or folds, erect from the surface of the bones and the roof of the skull. These by their intersection form an elaborate apparatus or labyrinth of thin plates and chambers lined with a vascular membrane well supplied with large blood vessels. Into the suprabranchial cavity atmospheric air is taken direct, the fish rising to the surface for the purpose of inhaling the air; if prevented from so doing it dies of suffocation, the gills alone apparently not being able sufficiently to oxygenate the blood. The suprabranchial chamber communicates with the branchial cavity by an opening above the two anterior gill slits, and may be separate from the pharyngeal cavity or in open communication with it, as in the Ophicephalidæ.

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[1] Philip. Journ. Sci. 24 (1914) 249 to 307.

Scales large to medium in size, ctenoid or cycloid; lateral line present and continuous or interrupted, vestigial, or absent; dorsal fin single, long, origin above or before base of pectorals and longer than anal, or shorter than anal and beginning behind base of pectorals; dorsal and anal with numerous spines of variable number or spines absent; ventrals thoracic, subabdominal, of six rays, the outer spinous in Philippine species; gills four; pseudobranchiæ none or rudimentary; pyloric appendages few or none; air bladder present or absent.

This order is confined to the fresh waters of the East Indies, southeastern and southern Asia, and tropical Africa. The various species have the power of being able to live out of the water for some time, or to live in semifluid mud, or even to lie in a half-torpid condition in the thick mud beneath the hard-baked crust of the bottom of a pond or water hole. They are not able, however, to live in mud from which all moisture has disappeared, as popular superstition credits them to be; when their gills are entirely dry they die as do other fishes.

Key to Philippine families of Labyrinthici.

a^1. Dorsal and anal without spines, of jointed rays only; scales cycloid; no labyrinthiform organ in suprabranchial cavity........ **Ophicephalidæ.**

a^2. Dorsal and anal with one to many spines; scales ctenoid; suprabranchial cavity with a labyrinthiform organ.

  b^1. Fixed conical teeth on palatines and jaws; vomer toothless; first soft ray of ventral produced into a single filament, or ventral reduced to a single long filament........ **Osphronemidæ.**

  b^2. Fixed conical teeth on vomer and jaws; none on palatines in Philippine representatives; ventrals of one spine and five soft rays. **Anabantidæ.**

OPHICEPHALIDÆ

Elongate and more or less cylindrical fishes, the posterior portion strongly compressed laterally; head large, depressed, covered above with very large shieldlike scales, those of the rest of the body of medium size, cycloid and much striated; all the fins lack spines; dorsal and anal long, undivided, with many rays, the pectorals large and the ventrals thoracic when present; the pelvic bones attached to the symphysis of the clavicles by a ligament; mouth large, upper lip protractile, though I have never seen a living fish extend it; maxillaries outside margin of mouth, bands of small or cardiform curved teeth on intermaxillaries, vomer, palatines, and mandibles; canine teeth also always present on mandibles and sometimes on vomer and palatines; lateral line nearly always curved more or less abruptly in its anterior half or may be partially interrupted; air bladder continued into an elongation of abdominal cavity in tail; four gills; gill rakers present but no pseudobranchiæ; gill membranes connected with each other but free from isthmus.

Above the gills is a large cavity, connected with the throat and serving as an accessory breathing organ. These fish go to the top and inhale air directly, the osmotic transfer of gases taking place through the mucous membrane that lines the cavity. In this way they are able to live in imperfectly oxygenated water or in mud, and to endure prolonged removal from water. Their position in the water is indicated by the bubbles which they expel at frequent intervals. So dependent are they upon the oxygen derived from directly inhaled air that they drown if kept in a vessel where they are prevented from coming to the surface of the water now and then.

This family includes two genera, and occurs from Formosa and Halmahera to Hindustan, Ceylon, and tropical Africa. But one occurs in the Philippines.

Key to the genera of Ophicephalidæ.

a^1. With ventral fins and two pyloric appendages.................... **Ophicephalus.**
a^2. Without ventral fins or pyloric appendages.................................... **Channa.**

Genus **OPHICEPHALUS** Bloch

> *Ophicephalus* BLOCH,[2] Ausland. Fische 7 (1793) 137. Type *Ophicephalus punctatus* Bloch.

Ventral fins are present and there are two long pyloric appendages. In other respects the characters are as given under the family Ophicephalidæ.

Key to the species of Ophicephalus said to occur in the Philippines.

a^1. Scales on top of head large.
  b^1. Four to five scales in transverse series from anterior part of dorsal to lateral line; dorsal 37 to 43; anal 21 to 27.
    c^1. Pectorals shorter than head behind eyes; lateral line 52 to 57. **O. striatus.**

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[2] Name altered by subsequent authors to *Ophiocephalus.*

c^2. Pectorals about as long as head behind eyes; lateral line 50 to 52. **O. melasoma.**

b^2. Three to three and one-half scales in transverse series from anterior part of dorsal to lateral line; dorsal 44 to 47; anal 28 to 31; head 3.5 to 3.8 times in length.......... **O. melanopterus.**

a^2. Scales on top of head small.......... **O. maculatus.**

Of the four species given in the key I have found but one in the Philippines. *Ophicephalus melanopterus* was recorded by Smith and Seale from Cotabato, Mindanao, but I have no doubt that their specimens were really *O. striatus.* Kner recorded *O. maculatus* among the fishes obtained by the Novara Expedition at Manila, but unquestionably this species does not occur in the Philippines, least of all at Manila. If there was no error in identification the material came from China, from whence alone this species is positively known.

Ophicephalus melasoma Bleeker.

Ophicephalus melasoma BLEEKER, Nat. Tijdschr. Ned. Indië 2 (1851) 424.

Ophiocephalus melanosoma GÜNTHER, Cat. Fishes Brit. Mus. 3 (1861) 473; BLEEKER, Atlas Ichth. 9 (1877) pl. 399, fig. 4; BOULENGER, Ann. & Mag. Nat. Hist. VI 15 (1895) 186; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 4 (1922) 319.

Dorsal 37–41; anal 21–25; pectoral 14–15; ventral 6; lateral line 50–52; scales in transverse series $\frac{4\text{–}4\frac{1}{2}}{8\text{–}9}$.

Depth 5 to 5.8, and 5.9 to 7.2 in length with caudal; head 3.1 to 3.3, and 3.8 to 4.2 in length with caudal; eye 5.7 to 7 in head, twice or a little less in interorbital space.

Cylindrical anteriorly, compressed posteriorly, head depressed, its upper profile straight, and interorbital space flat; snout less than twice diameter of eye; maxillary reaching from hind border of eye to far beyond eye; lower jaw slightly prominent, cleft of mouth rather oblique; a rather broad villiform band of teeth in intermaxillaries, teeth near angle coarser, especially the posterior ones; a patch of moderately strong teeth on vomer and an elongate band of strong teeth on palatines, the inner row largest and caniniform; several rows of teeth near symphysis of lower jaw, passing into a single row at sides, behind which are strong, widely spaced canines, all teeth curved backward; five or six scales in a row between eye and hind border of operculum and three to four rows on operculum; lateral line with an abrupt downward curve of three scales at fourteenth or fifteenth scale; fifteen to sixteen scales between tip of snout and origin of dorsal, which is behind base of pectorals; dorsal extends beyond tip of anal; pectorals about as long as from eye to posterior margin of head; ventrals as in *O. striatus.*

Color in alcohol dark greenish or bluish above, yellowish or reddish brown below; a rather inconspicuous dark oblique spot behind corner of mouth; underparts of head sometimes with yellow spots; pectorals, dorsal, and caudal dark, ventrals of the color of the lower parts, sometimes striped posteriorly; anal light, with a subterminal dark band. Attaining a length of 285 millimeters.

This species is included on the authority of Boulenger, who determined as such three specimens collected by Everett on Balabac Island. I have seen no material, the above description being compiled from Weber and Beaufort.

As in *O. striatus,* young specimens have a red lateral band from snout to caudal.

Ophicephalus melasoma occurs in the East Indies on the islands of Sumatra, Banca, and Borneo, and in Tonquin and Siam on the mainland.

Ophicephalus striatus Bloch.

Ophicephalus striatus BLOCH, Ausland. Fische 7 (1793) 141, pl. 359; CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 313, pls. 202 and 206.

Ophiocephalus striatus GÜNTHER, Cat. Fishes Brit. Mus. 3 (1861) 474; BLEEKER, Atlas Ichth. 9 (1877) pl. 399, fig. 1; SMITH, Bull. U. S. Fish Comm. 21 (1901) 171; JORDAN and SEALE, Proc. U. S. Nat. Mus. 28 (1905) 782; Bull. U. S. Bur. Fisheries 26 (1906) 27; EVERMANN and SEALE, Bull. U. S. Bur. Fisheries 26 (1906) 103; Proc. U. S. Nat. Mus. 31 (1907) 507; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 4 (1922) 317.

Ophiocephalus vagus PETERS, Monatsber. Akad. Berlin (1868) 260.

? *Ophiocephalus melanopterus* SMITH and SEALE, Proc. Biol. Soc. Washington 19 (1906) 79.

Dalag in Tagalog and many other Philippine dialects; *aluan* or *haluan* and *aruan* or *haruan* in Moro and Visayan; *haroan, torabó, terebog,* and *talosog* in Bikol; *bakule* and *bulig* are Tagalog names applied to young dalag.

Dorsal 37–43; anal 23–27; pectoral 15–17; ventral 6; lateral line 52–58; scales in transverse series $\frac{4}{8\text{–}10}$, not counting the lateral line.

Depth 5 to 6, head 3 to 3.3 in length without caudal, and 3.6 to 4 in total length; eye 4.4 to 8.5 in head, 1.6 to 2 in interorbital space, and 1.2 to 1.75 in snout.

The large broad head flat between eyes, upper profile but little convex, being more like an inclined plane; trunk hardly cylindrical but more or less flattened on sides even just behind head and strongly compressed posteriorly; eyes large, prominent, and somewhat projecting in life; the slightly oblique mouth large, the maxillary reaching well beyond eye, except in the very young (in a specimen 32 millimeters long it extends but a little beyond pupil); snout broad, rounded, lower jaw projecting; teeth in upper jaws (intermaxillaries) very small, recurved, in broad bands, tapering posteriorly, of from five or six to eight or nine rows, those behind symphysis fewer, coarser, longer, and some of them caninelike; teeth on vomer and palatines in about three or four rows, much larger than those on intermaxillaries, recurved, palatine teeth larger than those of vomer, some of them caniniform; teeth of mandibles in a patch of from three to five rows of teeth near symphysis, posteriorly with but one row of widely spaced canines larger than any of the other teeth in either jaw; pectorals shorter than postorbital part of head; lateral line with a downward curve, usually including three scales, at sixteenth to twentieth scale.

Color of specimens in alcohol above greenish or bluish to almost black, becoming white, silvery, or brownish beneath; dark streaks and blotches both above and below, including dorsal and anal fins and forming diagonal bars running forward and meeting at right angles on sides, these obscured or obsolete in old specimens; undersurface white, with dark or brown dots, dashes, and irregular or curved spots; a dark stripe from angle of mouth to suboperculum, sometimes fading and disappearing; pectorals dark, like the back; ventrals pale to whitish, spotted with dark brown or posterior half dark like the back; caudal very dark, or with crossbars of light and dark.

Color in life of a specimen raised from the egg, in my office, 375 millimeters long over all, pale muddy or brownish gray above and on sides with darker mottlings on head and dark brown bands or blotches across back and passing diagonally downward and forward to middle of side, where they may meet at right angles more or less clearly defined similar bars from below or be continued downward stopping at the white of belly and underparts, which are spotted with dark brown; a dark bar from corner of mouth backward and downward to opercle; dorsal fin clear to muddy, with flecks of brown; pectorals and ventrals colorless, with a few dark spots; anal and caudal very dark with a bronze greenish cast; eyes large, very prominent, with orange red iris.

Dalag is the most important fresh-water food fish in the Philippines, and occurs in lakes and lowland rivers throughout the islands from Siasi northward. While I have examined vast numbers of specimens from Jolo to Aparri, it is apparent that the original habitat of this fish did not include all the Philippine waters in which we now find it. Dalag abound in Lake Lanao but it is very evident that they have been planted there by the Moros. The Tagabilis claim to have taken them to Lake Sebu in the high mountains of southern Cotabato Province, while we know positively that they were carried by Christian Filipinos from Laguna de Bay, Luzon, to Lake Balinsasayao, the name applied to two small crater lakes at an altitude of about 1,050 meters in Oriental Negros, near Dumaguete. In like manner dalag have been distributed to lowland rivers and ponds all over the Islands, until they now occur wherever they can maintain themselves.

No systematic attempts have been made to cultivate dalag, though some of the Ifugaos stock their rice paddies with the fry and harvest them a few months later, while now and then some person attempts to grow them in a natural or artificial pond. The greatest obstacle to growing dalag commercially is their carnivorous habit and the difficulty of obtaining any cheap animal food in the Philippines. If this obstacle could be overcome they could be grown easily in large numbers.

Dalag are monogamous and reproduce during every month in the year in the Philippines, while unquestionably many, if not all, breed twice a year. The eggs are laid in a nest of water plants, usually some species of alga, in the center of which they float, lying flush with the surface of the water. They are of a golden yellow color, about a millimeter in diameter, and from five hundred or so to perhaps a few thousand in number.

One or other of the parents guards the nest at all times, lying concealed beneath it. The eggs hatch in two or three days and the fry swim about in a dense mass, protected by one or both parents, a single individual hardly visible except for its golden eyes. In a short time the fry assume a characteristic orange color and are very handsome lively little fish, incessantly journeying up and down in the water and emitting bubbles of air as they come to the surface. As they grow larger their color changes and the orange remains only as a longitudinal lateral stripe. The school remains together until the fry reach a length of 50 or 60 millimeters or more, always continuing the habit of coming to the top for air and diving beneath, but no longer doing so in unison, and more and more separating from each other.

As time goes on their numbers become greatly diminished. Of the original eggs, many do not hatch owing to the attacks of water fungi; while fungi, various parasites both internal and external, insects and insect larvæ, crustaceans, birds, and other fishes levy toll upon the fry. If food is scarce the adults gobble the young dalag as quickly as any other morsel.

With increased size the school scatters, each fish taking up a solitary abode, and the colors turn to brownish, with darker, diagonal, angled crossbars and a conspicuous dark ocellus at the posterior end of the dorsal; this gradually fades and the adult color and markings are assumed before the fish are a year old.

I have grown many in my office, and find that they become sexually mature in about eighteen months, when they may have a length of 250 millimeters or more. Specimens of the same age grown in ponds are much larger, however. As previously noted, one specimen raised in my office attained a length of 375 millimeters in two years and three months. Although this species is said by Weber and Beaufort to reach a length of over 900 millimeters, I have never seen any in the Philippines more than about 600 millimeters long. Such large, bulky specimens are several years old and are rare except in places such as Lake Lanao, Lake Balinsasayao, Liguasan marsh, or the overflow lakes of the Agusan Valley. In the vicinity of Manila they are fished for too constantly to reach any very great size.

Dalag are very hardy and are able to survive conditions fatal to most other kinds of fishes. They are able to endure prolonged removal from the water, and during rains voluntarily make long journeys across wet grassy or muddy ground, or along tiny rills or wet paths. In this way they reach isolated pools and flooded rice fields, although usually they reach the latter by following the irrigation ditches. Unobservant people, finding them in rice paddies which a few days before were dry and hard, have spread wide the delusion that they were buried in the sun-baked mud during the dry season or have rained down.

When the water has been drawn off or has evaporated until there remains but a pool of liquid mud, dalag are still able to survive for a long time, burrowing down in the mud for a foot or two; even after the surface of the mud has been caked over they will live as long as it is moist beneath.

Dalag take the hook readily, frogs being a particularly attractive bait. Large numbers are also taken in swamps and rice paddies by the aid of a conical woven trap, open at both ends, with the ribs projecting at the larger end for several inches. The person using it wades about, keeping a sharp lookout for bubbles of air which betray the presence of a dalag beneath. When these are seen the trap is plunged down into the mud over the spot where the bubbles were observed and, by feeling about with the hand in the inclosed space, the fish is forthwith caught.

Although foreigners usually have a violent prejudice against eating dalag, they are really good food when properly prepared and have the great merit of being strictly fresh, since in most markets they are kept alive until sold, the market women having to stun them with a club before the customer can carry them readily.

Owing to their voracity, rapid reproduction, and quick growth, they play great havoc upon gaining entrance to ponds or preserves stocked with other fishes. Anyone engaging in the culture of other fresh-water fishes must be sure that there are no dalag left in the water to be stocked, and care must be taken that none can get in later.

Dalag occur from Ceylon and Hindustan east to Flores, Amboina, Batjan, and Halmahera, and northward to southern China, from whence they were introduced into Oahu Island; they are common about Honolulu. I have no doubt that their extension in the East Indies eastward beyond Lombok has been due wholly to man's agency, while it is most probable that Borneo and Mindanao mark the limit of their natural range.

OSPHRONEMIDÆ

Compressed or strongly compressed, oblong to elongate, often very broad fishes, without teeth on the palate and with the first soft ray of each ventral produced into a single elongated filament; the ventral may consist of a spine and five rays, or may be reduced to a single filamentous ray and a rudimentary spine; lateral line complete and continuous or interrupted, vestigial, or absent; scales moderate to large, ciliate; dorsal shorter than anal, its origin behind or above that of anal; origin of ventrals below or in advance of the pectorals.

Fresh-water fishes of the East Indies and tropical Asia and Africa, many of them very small, and noted for their beauty or their pugnacity. One, the gourami, attains a large size and is celebrated for its excellent flavor; it is the best of all Asiatic tropical food fishes. It has been introduced into many parts of the world and would be a valuable addition to the fish fauna of the Philippines, since it thrives under pond culture.

Genus **TRICHOGASTER** Bloch and Schneider

Trichogaster BLOCH and SCHNEIDER, Syst. Ichth. (1801) 164; type as restricted by Cuvier & Valenciennes, *Labrus trichopterus* Pallas.

Trichopodus LACÉPÈDE, Hist. Nat. Poiss. 3 (1802) 129: (*trichopterus*).

Trichopus SHAW, Gen. Zool. 4 (1803) 392: emendation: same type.

Body strongly compressed and oblong; mouth very small, very oblique, the somewhat protractile upper jaw vertical when at rest, lower jaw prominent; bands of minute fixed teeth in both jaws, a few larger ones in outer row; preorbital and preopercle strongly spinous, lower margin of subopercle serrate; opercle terminating in a membranous posterior flap; dorsal much shorter than anal, with three to eight spines and eight to eleven rays; origin of anal about below base of pectorals, with nine to fourteen spines and twenty-five to thirty-nine rays, extending to base of caudal and with a wide basal scale sheath; origin of ventrals in advance of pectorals, composed of a vestigial spine, a greatly elongated simple filament which is the modified first ray, and two or three rudimentary rays; lateral line complete but more or less curved and irregular; scales of moderate size, diagonally and more or less irregularly arranged.

Small fishes of the East Indies from Sumatra to Borneo and occurring also in Cochin China, Siam, and the Malay Peninsula.

Trichogaster trichopterum (Pallas). Plate 1.

Labrus trichopterus PALLAS, Spicil. Zoolog. 8 (1777) 45.

Trichopodus trichopterus LACÉPÈDE, Hist. Nat. Poiss. 3 (1802) 125 and 129; BLEEKER, Atlas Ichth. 9 (1877) pl. 395, fig. 4; REGAN, Proc. Zool. Soc. London (1909) 783; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. 4 (1922) 366, fig. 93.

Trichopus trichopterus CUVIER and VALENCIENNES, Hist. Nat. Poiss. 7 (1831) 290, pl. 199.

Osphromenus insulatus SEALE, Philip. Journ. Sci. § A 4 (1909) 530.

Dorsal VI–VIII, 7–10; anal X–XII, 30–38; lateral line 30–40.

Depth 2 to 2.6, head 2.7 to 3.2 (3.4) in length; head somewhat pointed, upper profile straight or slightly concave; diameter of eye equal to or much more than length of snout, 3⅙ to 3.6 in head; pectoral as long as head; dorsal short, its origin over the spinous anal, its basal length equal to or less than distance from posterior end of dorsal base to base of caudal; ventral filament extending to caudal base; lateral line curved, irregular, more or less broken, with thirty-one to thirty-four tubule-bearing scales in our specimens.

> Color in life brown with some irregular blackish marks on shoulders, some yellowish on opercles and on thorax, some vivid pink at base of anal, * * *. Dorsal yellowish brown in females, brown in males, the rays marked with yellowish dark-ringed spots. Caudal brown, with numerous yellowish spots, anal brown with some yellowish spots, pectorals brown, ventrals yellowish, a distinct black spot at base of caudal, another on middle of side.—*Seale.*

Color in alcohol dull dark brown, becoming paler on sides and silvery on breast, with many pale, irregular, narrow, somewhat diagonal crossbands on sides; a large black spot surrounded by a pale area on middle of side and a similar one at base of caudal; caudal and posterior half of anal with alternate series of pale and dark spots; soft dorsal with similar, very faint spots.

Here described from twelve specimens, 30 to 64 millimeters in length, collected by Alvin Seale in 1908 from a small crater lake on Cagayan Sulu. Since none of them is mature the specimens differ somewhat in detail from larger specimens. None of them has over thirty-three rays in the anal, while the eye is relatively much larger than in adults, in which it is about 4.5 times in the head.

This species, which reaches a length of 120 millimeters, occurs from Singapore and Sumatra to Borneo and Bali, and on the mainland in Cochin China, Cambodia, Siam, Penang, and throughout the Malay Peninsula.

ANABANTIDÆ

Body oblong, compressed, with broad to very broad head; preorbital, operculum, suboperculum, and interoperculum serrated, or denticulated; the small, oblique mouth extends to below eye; teeth small, conical, fixed, in bands on jaws and vomer, and in one genus on palatines; scales large, regularly arranged, ciliate; dorsal with sixteen to twenty spines and seven to eleven rays; anal with eight to eleven spines and eight to twelve rays; spinous portion longer than soft dorsal and anal, the rays scaled basally; pectorals and caudal rounded; ventrals thoracic, inserted behind pectorals, with one spine and five rays, none of them elongated; cæcal appendages none to three.

Two genera, one in the East Indies and tropical Asia, the other in tropical Africa.

Genus **ANABAS** Cuvier

Anabas Cuvier, Regne Anim. ed. 1a (1817) 339.

This genus is separated from *Ctenopoma* by the absence of teeth on the palatines; in other respects the characters are sufficiently defined above.

Found in the fresh waters of the lowlands throughout southern and southeastern Asia and the adjacent islands, from Ceylon and Hindustan to southern China, Batjan, and Halmahera.

Anabas testudineus (Bloch).

Anthias testudineus Bloch, Ausland. Fische 7 (1795) 121.

Perca scandens Daldorff, Trans. Linn. Soc. 3 (1797) 62.

Anabas testudineus Cuvier, Regne Anim. ed. 1a 2 (1817) 310; Peters, Monatsber. Akad. Wiss. Berlin (1868) 259; Bleeker, Atlas Ichth. 9 (1877) pl. 396, figs. 2 and 3, Mem. Poiss. Pharyng. Labyrinth., Nat. Verh. Kon. Akad. 19 (1879) 7; Jordan and Seale, Proc. U. S. Nat. Mus. 28 (1905) 782; Jordan and Richardson, Bull. U. S. Bur. Fisheries 27 (1907) 262; Weber and Beaufort, Fishes Indo-Austr. Arch. 4 (1922) 344, figs. 2 and 3.

Anabas scandens Cuvier and Valenciennes, Hist. Nat. Poiss. 7 (1831) 249, pls. 193, 205, and 206; Günther, Cat. Fishes Brit. Mus. 3 (1861) 375; Smith, Bull. U. S. Fish Comm. 21 (1901) 170; Smith and Seale, Proc. Biol. Soc. Washington 19 (1906) 79; Regan, Proc. Zool. Soc. London (1909) 771.

Anabas macrocephalus Bleeker, Nat. Tijdschr. Ned. Ind. 7 (1854) 430; Günther, Cat. Fishes Brit. Mus. 3 (1861) 376.

Anabas oligolepis Bleeker, Nat. Tijdschr. Ned. Ind. 8 (1855) 161; Günther, Cat. Fishes Brit. Mus. 3 (1861) 376; Bleeker, Atlas Ichth. 9 (1877) pl. 395, fig. 5.

Anabas microcephalus Bleeker, Act. Soc. Sc. Indo-Neerl. 2 (1857) 58; Günther, Cat. Fishes Brit. Mus. 3 (1861) 377; Bleeker, Atlas Ichth. 9 (1877) pl. 395, fig. 2.

Climbing perch; *martinico* in Filipino Spanish; *martinik* and *tinikan* in Tagalog; *liwaló* in Pampangan; *araró* in Ilocano; *gután* in Visayan; *puyo* in Bicol; *puyo* in Maguindanao Moro and *puyo* or *puyo-puyo* in Manobo, Bagobo, Mandaya, and other Mindanao languages; *piit* in Tao Sug or Joloano Moro.

Dorsal XVI–XX, 8–10; anal IX–XI, 8–11; pectoral 14–16; ventral I, 5; lateral line 26–30 (32, auctt.); scales in transverse series $\frac{3\text{–}4}{8\text{–}11}$.

Depth 2.25 to 3.2 in length; head 2.7 to 3.3 in length; eye 4 to 6 in head, equal to or a little more than snout.

The form is variable, as age and amount of food cause much alteration in bodily appearance and proportions, but it is always more or less compressed, with a broad to very broad subcylindrical head. In a specimen 28 millimeters long the head is 2.5 in the length, and in one 18 millimeters long it is 2.25 times in the length. The dorsal and ventral profiles are very much alike, moderately or slightly convex, the interorbital space broad to very broad, often flat; head scaled, with four or five rows of scales between eye and rear margin of preoperculum; operculum, suboperculum, interoperculum, and preorbital margined by long stout divergent spines, less well defined in the young, and few or absent in very young specimens; preoperculum with a few spines on lower posterior border; jaws equal or sometimes lower one slightly prominent; jaws with narrow bands of small crowded teeth and a wedge-shaped row of slightly larger teeth on vomer; anterior nostril with a tube, none on the larger posterior nostril; origin of dorsal over hind margin of opercle or over the short pectoral; dorsal and anal spines strong, sharp, shorter than the rays; first dorsal spine shortest, third or fourth and three or four immediately following longest; origin of ventrals behind that of pectorals; caudal rounded; lateral line interrupted below hinder part of spinous dorsal, and continued on second scale row beneath back to caudal.

Color in life dark to pale greenish, belly and throat very pale, back dusky to dark olive, with a transverse band of warm reddish brown on top of head; longitudinal stripes of alternate silvery and dark greenish on jaws, chin, and throat; a triangular dark spot on posterior margin of opercle and a row of small dark spots passing over head to opposite side; a similar but smaller row passing forward and crossing over head behind eyes; posterior half of body with rather vague vertical crossbands; a large circular spot at base of caudal; dorsal spines dark, the rays pale, as are all the other fins; dark spot at base of each dorsal spine; iris golden reddish.

In the interior of Cotabato Province, especially in Lake Buluan and the rivers between it and the town of Cotabato, there occur many albino climbing perch, varying from brass color to pure golden and orange; occasionally one sees particolored specimens, with spots of dark greenish here and there amid the general brassy yellow. No other author seems to have noted this condition except Francis Day, who obtained a single orange-colored specimen in the Ganjam District, India. In 1921 Governor Unson, of Cotabato, sent me two living albinos. One was injured en route and lived but a month; the other is still alive in the Bureau of Science Aquarium. Mr. Vallodolid, instructor in zoölogy at the College of Agriculture at Los Baños, has a living albino 230 millimeters long, which was brought to him by a student who obtained it from Lake Buhi, Camarines Sur Province.

Color in alcohol greenish or greenish olive to dark brown, uniform or paler below; a large dark spot usually present at base of caudal and a small one at posterior margin of opercle; posterior half of body often with faint transverse markings; fins brownish or dark. Albino specimens in alcohol become much paler than they were in life.

This remarkable fish occurs in slow streams, ditches, ponds, and lakes throughout the Islands, but does not occur in the mountains and, unlike dalag, has not been planted in elevated lakes. I have examined many specimens, ranging in length from 18 to 156 millimeters. My largest specimen is 190 millimeters long over all, but the species reaches a total length of 230 millimeters. The statement quoted by Smith (l. c.) that it attains a weight of two pounds in Lake Buhi is not borne out by the facts, specimens of 230 millimeters in length being very rare there.

The climbing perch is highly variable, and there can be no doubt that but one species is recognizable. The usual number of dorsal spines is from seventeen to nineteen, but sixteen is not rare, while one of my albino specimens has twenty. Weber and Beaufort give the number of transverse scales below the lateral line as seven to ten.

The thin delicate plates composing the labyrinth in the cavity above the gills vary much in their development, according to the age of the animal. In very small specimens there are but two of the thin, bony, straight-edged plates, but with advancing age more are added, so that in large specimens there may be half a dozen concentrically arranged laminæ with undulated and curtainlike edges.

Ever since 1791, when Daldorff captured a climbing perch in the act of ascending the trunk of a palmyra growing near a pond, this fish has been celebrated for its ability to live out of the water and to move about freely upon the land.

The animal seems to have two distinct modes of locomotion when out of the water. In one method, which closely resembles that used by many other fishes, the body is held up by the pectorals, the opercles are extended at nearly right angles to the body, and by means of the caudal the fish leaps or glides along rapidly. In the other method the body is inclined to one side, so that the sharp spines of the subopercle come in contact with the surface; the closing of the opercle then pulls the body forward, its progress being assisted by the movements of the caudal, the anal, and the pectorals. In this manner it is able to make its way over long distances and to surmount very considerable obstructions, or even to ascend for a meter or two the rough trunk of certain palms.

During the dry season the climbing perch is able to survive in very small pools of semiliquid mud. Since it takes the hook greedily, it is common in the dry season to see someone fishing in what seems to be a dry field of waving grass. Out of a small puddle in such a place may be caught one or two dozen fish. In spite of their small size and many bones they are much prized as food, especially in the interior along the great rivers and in swampy regions, and large quantities may be seen alive at nearly all times in the Manila markets. It is claimed that this fish is able to survive as long as six days out of water.

As alrealy indicated, their present range is no indication of their natural distribution, since Hindu and Malay migratory boatmen have the habit of carrying them alive with them. In this manner they have been distributed far to the eastward of their native habitat, as was pointed out by Regan in 1909.

Order NEMATOGNATHI

CATFISHES

The catfishes are recognized at once by their naked body covered with thick, slimy skin, or with bony plates on the head in some of the Philippine species, but never with scales, and by their long feelers, or barbels, borne by the rudimentary maxillaries.

As only the exclusively fresh-water families of catfishes are here presented, a full diagnosis is deferred until a revision of all the Philippine members of the order shall have been completed.

Key to the families here described.

a^1. Dorsal spineless, with many rays; anal very long; four pairs of barbels present; top of head with bony plates.................................. **Clariidæ.**

a^2. Dorsal spineless, very short, rudimentary, or absent; anal very long; two or three pairs of barbels; no bony plates on head........ **Siluridæ.**

CLARIIDÆ

The body is long and eel-like, with a much flattened head, the top and sides of which are covered with plates of bone; below these is a cavity, an offshoot of the gill chamber, which contains dendritic accessory breathing organs that are attached to the second and fourth gill arches; in the bony roof of the brain cavity are two fontanels, or openings, an occipital and a frontal one, covered only by skin. There are four pairs of barbels, nasal, maxillary, and two on the mandible; the anterior nostrils are in short tubes behind the upper lip, and the posterior ones are more or less rounded slits behind the nasal barbels; the eyes are small and have a free margin; the dorsal and anal are both very long, extending to or united with the caudal, of soft rays only, or the dorsal may be short and followed by an adipose fin; only the pectoral has a sharp spine; ventrals with six rays; jaws with more or less united patches of very fine teeth, a crescentic band of similar teeth on the vomer; skeleton soft, cartilaginous.

Fishes of muddy streams, ponds, swamps, and rice paddies in the East Indies, Formosa, Africa, and the intervening parts of Asia; the Philippine species are all small, though some members of the family are very large, reaching a length of nearly 2 meters.

Genus **CLARIAS** (Gronow) Scopoli

Clarias Gronow, Zoophyl. (1763) 100; Scopoli, Introd. Hist. Nat. (1777) 455.

Dorsal very long, its origin at nape, extending nearly or quite to caudal, with which it may be united; gill slits very wide, gill membranes free from isthmus; gill rakers seventeen to nineteen; branchiostegals seven to nine, air bladder small, transverse, lobed, encased in bone. In other respects the characters are those of the family. The number of bony plates on the top and sides of the head is variable, even in the same species. Young specimens have fewer plates, additional sutures appearing with age, so that large old fishes may have many more plates than young ones.

Key to the Philippine species of Clarias.

a^1. Dorsal and anal free from caudal; head with fifteen to seventeen bony plates .... **C. batrachus.**
a^2. Dorsal and anal united to caudal, at least at its base; head with twenty-one bony plates .... **C. gilli.**

Clarias batrachus (Linnæus).

Silurus batrachus LINNÆUS, Syst. Nat. ed. 10 **1** (1758) 305.

Clarias batrachus BLEEKER, Atlas Ichth. **2** (1862) 103, pl. 98, fig. 2; PETERS, Monatsber. Akad. Wiss. Berlin (1868) 271; WEBER and BEAUFORT, Fishes Indo-Austr. Arch. **2** (1913) 190, fig. 74.

Clarias magur GÜNTHER, Cat. Fishes Brit. Mus. **5** (1864) 17; JORDAN and SEALE, Bull. U. S. Bur. Fisheries **26** (1906) (1907) 8.

Catfish. *Hito* in Tagalog; *paltat, pantat,* and *pa'tat* in Ilocano and other languages of northern Luzon.

Dorsal 60–76; anal 47–58.

Body elongate, with strongly sloping depressed head, very low anteriorly, and rather short, rounded caudal which is free from both dorsal and anal; depth 5 to 5.8, head to gill opening 4.4 to 4.7 in length; eyes small, with free orbital margin, 9 to 14 in head; dorsal profile an almost straight line from tip of snout to posterior end of head; top of head gently convex transversely and composed of fifteen bony plates, this number increasing to seventeen or more (twenty-three?) in old specimens; the large central frontal plate with a fontanel, or opening, extending at least as far forward as middle of eyes (in one specimen wholly behind eyes), and more than twice as long as fontanel of the large occipital plate; all plates more or less granular beneath their covering; teeth very small, those of maxillaries smallest, in a rather wide band, those on vomer in a broader, crescent-shaped band; teeth on mandibles in two somewhat quadrangular bands with the outer posterior angle produced laterally, separated by a narrow but well-defined groove; barbels long, the nasal extending almost or quite to occipital fontanel, the other barbels extending upon or to middle of pectorals, the maxillary pair sometimes still longer; pectoral spine stout, sharp, smooth or sometimes a little roughened, covered with skin except near its tip, about three-fourths as long as pectoral fin; height of dorsal $\frac{1}{3}$ to 0.4 length of head.

Color in life dark, more or less bluish black, belly and throat pale or whitish; usually with vertical rows of white spots along sides from dorsal to lateral line and a longitudinal row or partly double row of similar spots beginning behind pectoral and running low down on side to caudal peduncle.

Color in alcohol similar, or becoming uniform brown.

I have examined many specimens, from 45 to 235 millimeters long, from the following localities: Tuao and Aparri, Cagayan; Vigan and Santa Maria, Ilocos Sur; Pampanga and Bulacan Provinces; Manila; Cavite, Cavite; and Jaro, Leyte. My largest specimen measures 270 millimeters over all.

Large numbers of this species are brought alive to the Manila market, where they can be seen at nearly all times of year; Tarlac and Pampanga furnish the chief supply. Though I have seen specimens from Luzon and Leyte only, the species has been recorded from Catbalogan, Samar, by Peters, and it doubtless occurs in other islands. Two kinds of catfish are said by the Maguindanao Moros to live in the ponds and swamps of the Pulangi, Cotabato Province, and it may be that *C. batrachus* is the second species, as *C. gilli* is the only one in collections from that region.

This fish lives in swamps, ponds, ditches, rice paddies, and the pools left in low spots after rivers have been in flood. Though far from a handsome fish its flesh is good and is much esteemed by the people of the western part of central and northern Luzon. When very small it is called *pantat* by the Tagalogs, a name applied to the adults by some of the people of northern Luzon, while very large adults are called *hitong batukan.*

Occasionally albino specimens occur in the swamps of Bulacan, Pampanga, and Tarlac, and for several years living albinos have been kept in the Bureau of Science Aquarium. They vary in color from yellow to whitish yellow, either with or without irregular dark blotches of the ordinary color.

This species is said to reach a length of over 400 millimeters, and occurs from the Philippines through Borneo to Sumatra and throughout the Malay Peninsula to Ceylon and Hindustan.

Clarias gilli Smith and Seale.

Clarias gilli SMITH and SEALE, Proc. Biol. Soc. Washington 19 (1906) 74, text figure.

? *Clarias nieuhofi* GÜNTHER, Cat. Fishes Brit. Mus. 5 (1864) 20, p. p.; PETERS, Monatsber. Akad. Wiss. Berlin (1868) 271.

Balika or *balik* in Maguindanao Moro.

Dorsal 88–94; anal 71–87; ventral 5.

Depth 8.3 to 9.8, head 6.6 to 6.7, tip of snout to posterior margin of occipital process 5.4 to 5.6 in length; distance from dorsal to occipital process 2 to 2.4 in distance from occipital process to tip of snout; eye very small, 16 to more than 17 in head, with a free orbital margin; dorsal thick, low, its height 3.5 to 4 in head and equal to or nearly equal to the small short ventrals, which are 3.4 to 3.7 in head; dorsal and anal confluent with caudal.

Body very elongate and eel-like, apparently with a distinct neck, the depth of posterior part of head more than that of body between head and beginning of dorsal; trunk very short, less than a fourth of total; tail deeper than trunk, 0.61 to 0.62 of length; head much depressed anteriorly; upper profile nearly straight from snout to posterior extremity of head and nearly flat in the middle, gently convex from side to side; top of head with twenty-one bony plates, the frontal fontanel far behind eyes and larger than the occipital one; barbels long, maxillary reaching nearly or quite to tip of pectoral, which is very short, its sharp spine smooth or granular and covered with thick skin; teeth all small, villiform, those of maxillaries in a quadrangular curved band; teeth on vomer somewhat larger, in a broad, somewhat crescent-shaped band, middle of posterior border with a prominent extension; teeth on mandibles still coarser forming a broad angular band with the outer posterior corners much extended backward and a narrow groove extending from behind forward along median line, nearly or quite dividing it in two.

Color in life bluish black, belly and throat paler to whitish; in alcohol turning brown to yellowish brown.

Here described from two specimens, respectively 335 and 345 millimeters long, collected by me in the market at Tituan, a barrio on the Rio Grande de Mindanao, Cotabato Province. In addition to other specimens obtained there, I also collected this species in Malupali River at Mailag, Bukidnon, and in a brook near Santa Fe, Bukidnon, the last at an approximate elevation of 615 meters. My largest specimen is 378 millimeters over all, my smallest 113 millimeters, or 130 millimeters including the caudal. Small specimens are not so slender and have the eye larger in proportion.

I also refer here provisionally four medium-sized to large specimens collected by Alejo Arce at Lake Batu, Camarines Sur Province, and a large specimen of unknown origin. In some of these the frontal fontanel is partially divided by a bony ridge so that it is superficially, at least, almost two. Smith and Seale give a figure showing *C. nieuhofi* with but eight bony plates on the top and sides of the head, and with two fontanels in the frontal plate, thus agreeing with Bleeker's figure of that species. If this is correct, the Philippine specimens referred by Günther and Peters to *C. nieuhofi* are probably *C. gilli.* Only an examination of the type of *C. nieuhofi* will decide the validity of *C. gilli* as a distinct species.

Clarias gilli is common over Mindanao and seems to occur also in southeastern Luzon; no other locality is known.

SILURIDÆ

Elongate fresh-water catfishes with more or less strongly compressed bodies, the head conical or with a depressed snout, and without bony plates or scutes; only two pairs of barbels are ordinarily present, a maxillary and a mandibular, but there may be an additional pair behind the chin; the dorsal is short or may be either rudimentary or altogether wanting; there is neither dorsal spine nor adipose fin; a spine is always present on the pectoral; the small ventrals are below or behind the dorsal or may be rudimentary or absent; the anal is long, with many rays, and extends nearly to the caudal or is more or less completely united with it; the caudal is deeply and obliquely forked, emarginate, or rounded; the teeth are villiform, except in one genus in which they are widely set and long, in bands on the jaws, in one or two patches on the vomer, and absent on the palatines except in the two new genera here included; branchiostegals nine to twenty; the gill membranes are more or less overlapping, free from each other and from the isthmus.

Key to the Philippine genera of Siluridæ.

a^1. With one pair of barbels under chin.. **Hito.**
a^2. With two pairs of barbels under chin...................................... **Penesilurus.**

Genus HITO novum

Body narrow, strongly compressed, with broad, stout head and moderately depressed snout, dorsal profile convex to nearly straight; mouth wide, nearly horizontal, with subequal jaws or the lower slightly projecting; teeth minute, villiform, depressible, in bands on jaws, usually divided by a narrow median groove, a single narrow transverse band on vomer, and a small patch on each palatine; anterior nostrils tubulate, posterior with an incomplete elevated margin which becomes a flap on anterior side; eyes covered by skin, behind angle of mouth; a pair of maxillary and a pair of mandibulary barbels, the latter some distance behind point of chin; between them a fold of skin which forms a wide rounded crypt under chin; dorsal fin with four rays, its base very short; pectorals with a spine; ventrals small, below dorsal; anal very long, not united to caudal; branchiostegals twelve to fourteen; gill rakers fourteen; gill membranes free from each other and from isthmus.

Close to *Silurodes* Bleeker, but with teeth on the palatines and a different number of branchiostegals.

Type of the genus, *H. taytayensis* sp. nov.

Hito, a Filipino name for certain catfishes.

Hito taytayensis sp. nov.

Dorsal 4 or 3; anal 57–61; pectoral I, 11; ventral 7; branchiostegals 12 to 14; gill rakers 14.

Depth 5 to 5.5, head equal to trunk and 4.9 to 5 in length; eyes 6.2 to 7.2 in head, about 3 in the broad, blunt, somewhat rounded snout, and about 4 in the convex interorbital space; eyes opposite, or lower margin opposite angle of mouth, from which they are a diameter distant; anterior and posterior nostril on each side an eye diameter apart; jaws equal or the lower one slightly projecting; bands of teeth on jaws widest posteriorly, narrow and with or without a median groove at symphysis; teeth on vomer larger, in two to four rows; patches on palatines elongate or oval, or sometimes reduced to mere asperities on one side at least; barbels short, maxillary 3.7 to 4 times in length, those on mandible much shorter than head, 7 to 9 or even 13 times in length; dorsal fin very small; pectorals short, not extending as far back as to ventral, 6.6 to 7.5 in length, pectoral spine about two-thirds as long as fin, stout, sharp-pointed, smooth on anterior but serrate on posterior surface; the very small ventrals behind dorsal do not extend upon anal, only reaching its base; anal very long, wide, prominent, free from base of forked caudal which is as long as head.

Color in alcohol uniform yellowish brown, everywhere sprinkled with minute dark brown specks; a large dark blotch on side between lateral line and pectoral; fins all colorless.

Here described from the type, No. 9357 Bureau of Science collection, and seventeen cotypes, collected from a small freshwater creek near Taytay, Palawan, in May, 1913. The type and largest specimen is 100 millimeters long or 120 millimeters including caudal; the smallest of the lot is 58 millimeters in length.

Genus **PENESILURUS** novum

Body elongate, strongly compressed, with broad, rounded head, dorsal profile nearly straight; dorsal fin vestigial, of two partly united filaments, before the small ventral of six rays; no adipose fin; mouth terminal, large, lower jaw slightly projecting; eyes subcutaneous, situated behind corner of mouth;

anterior nostrils slightly tubulate; posterior nostrils with a small anterior marginal flap; pectorals with a spine; anal long, wide, ending at base of caudal; one pair of long maxillary barbels and two pairs of mandibulary barbels far behind symphysis, the anterior pair nearer median line; teeth villiform, in bands on jaws, in a single straight band on vomer; a small patch on palatines; ten branchiostegals; fifteen gill rakers, the gill membranes free from the isthmus.

Pene, almost; *Silurus*, a genus of catfishes, from the classical name of the European sheatfish.

Type of the genus, *P. palavanensis* sp. nov.

This genus is distinguished from the closely related *Hito* by the extra pair of mandibulary barbels.

Penesilurus palavanensis sp. nov.

Dorsal 2; anal 55; pectoral I, 11; ventral 6.

Depth 5.14, the broad, low head as long as trunk and 4.7 in length of the compressed body; tail more than 0.57 of length; head nearly flat, gently rounded from side to side, with a wide, broadly rounded snout; eyes extend below level of corner of mouth, from which they are distant an eye diameter; eye 7$\frac{2}{3}$ in head, 3 in snout, and 4 in the broad interorbital space; anterior nostrils slightly anterior to maxillary barbels, posterior nostrils an eye diameter behind anterior ones; maxillary barbel long, extending nearly to tip of pectoral, a trifle more than 3 times in length; the mandibulary barbels about equal in length, each extending upon the pectorals, 6 or nearly 6 in length, anterior barbel an eye diameter from the posterior, more external one; a broad thick fold of skin forms a deep Λ-shaped crypt under chin, its apex between the anterior pair of barbels; teeth minute, depressible, curved, those of intermaxillaries in two bands separated by a narrow toothless groove, and broadest posteriorly; teeth on vomer somewhat larger, in a nearly straight band of two rows; a patch of teeth on left palatine but not on right, which has merely a roughened spot; teeth on mandibles in a wide uniform band; dorsal vestigial, basally coalesced, with two tiny projecting filaments; pectoral spine stout, sharp, inner surface minutely denticulate, five-ninths as long as pectorals, which are contained 6 times in length; ventrals small, badly broken in my specimen, only the bases of the six rays left; anal broad, ending just before base of caudal, of which only the stump is left.

Color in alcohol pale yellowish brown, the fins very pale.

Here described from a specimen 108 millimeters long in poor condition, caught with hook and line by Prof. A. L. Day at Lake Manguao, Palawan, in May, 1913.

SUMMARY OF PHILIPPINE TRUE FRESH-WATER FISHES

CYPRINIDÆ

ABRAMIDINÆ

Genus **NEMATABRAMIS** Boulenger

1. **verecundus** Herre; Titunod River, north coast of Mindanao.
2. **alestes** (Seale and Bean); Zamboanga, Mindanao; Puerto Princesa and Taytay, Palawan; Busuanga.
3. **everetti** Boulenger; Palawan.

RASBORINÆ

Genus **RASBORA** Bleeker

4. **taytayensis** Herre; Taytay, Palawan.

4a. **lateristriata** Bleeker; Malum River, Tawitawi.

5. **punctulatus** Seale and Bean; Zamboanga, Mindanao.
6. **argyrotaenia** Bleeker; Busuanga; Lake Manguao and Puerto Princesa, Palawan.
7. **philippina** Günther; Zamboanga and Cagayan de Misamis, Mindanao.

CYPRININÆ

[Genus **CYPRINUS** Linnæus]

[**carpio** Linnæus; naturalized in rivers of Cotabato Province and Lake Nunuñgan, Lanao Province, Mindanao.]

Genus **MANDIBULARCA** Herre

Corpus oblongum sat compressum; venter latum; rostrum brevis latum haud prominens; mandibulum spatulatum, angustum, tenuis, prominens, elongatum, resimum; labia inferiore tenuis vel nulla; cirri 4.

8. **resinus** Herre; type of the genus; Agus River, Lake Lanao, Mindanao.

Genus **HAMPALA** Bleeker

9. **lopezi** Herre; Busuanga.

Genus **CEPHALAKOMPSUS** Herre

Corpus oblongum elongatum compressum; venter rotundatum; caput et rostro magnum et incultum; labiae crassae rugosae; sulcus postlabialis unicus margini maxillae libero parallelus formam rictus referens; pinna dorsalis ante ventrales; spina dorsalis gracilis paulo denticulata; squamae magnae, 3½ inter lineam lateralem et pinna dorsalis; plicones sensoram capitis nulli; cirri 4, robusti.

10. **pachycheilus** Herre; type of genus; Lake Lanao, Mindanao.

Genus **OSPATULUS** Herre

Corpus crassum robustum, venter rotundatum; caput inferiore latissimus; mandibulum brevis, maxillae superiores non attingente, speciam os patulum; pinna dorsalis basi non vel paulo squamosa, ante ventrales, spina gracilis paulo denticulata; sulcus postlabialis subtus mentum interruptus; cirri 4.

11. **truncatulus** Herre; type of genus; Lake Lanao, Mindanao.
12. **palaemophagus** Herre; Lake Lanao, Mindanao.

Genus **BARBODES** Bleeker

13. **hemictenus** Jordan and Richardson; Mindoro.
14. **ivis** (Seale); Palawan; Balabac; Busuanga.
15. **tumba** Herre; Lanao Plateau, Mindanao.
16. **quinquemaculatus** (Seale and Bean); Zamboanga, Mindanao.
17. **binotatus** (Cuvier and Valenciennes); all of Mindanao except the Lanao Plateau.
    var. **palavanensis** (Boulenger); Palawan.
18. **montanoi** (Sauvage); Simulao River, Agusan Province, Mindanao.
19. **clemensi** Herre; Lake Lanao, Mindanao.
20. **amara** Herre; Lake Lanao, Mindanao.
21. **flavifuscus** Herre; Lake Lanao, Mindanao.
22. **manguaoensis** (Day); Lake Manguao, Palawan.
23. **bantolensis** (Day); Lake Manguao, Palawan.
24. **lanaoensis** Herre; Lake Lanao, Mindanao.
25. **katolo** Herre, Lake Lanao, Mindanao.
26. **manalak** Herre; Lake Lanao, Mindanao.
27. **lindog** Herre; Lake Lanao, Mindanao.
28. **palata** Herre; Lake Lanao, Mindanao.

Order LABYRINTHICI

OPHICEPHALIDÆ

Genus **OPHICEPHALUS** Bloch

29. **melasoma** Bleeker; Palawan.
30. **striatus** Bloch; general throughout the Philippines.

OSPHRONEMIDÆ

Genus **TRICHOGASTER** Bloch and Schneider

31. **trichopterum** (Pallas); Cagayan Sulu.

ANABANTIDÆ

Genus **ANABAS** Cuvier

32. **testudineus** (Bloch); generally distributed.

Order NEMATOGNATHI

CLARIIDÆ

Genus **CLARIAS** (Gronow) Scopoli

33. **batrachus** (Linnæus); Luzon and Leyte.
34. **gilli** Smith and Seale; Mindanao; Lake Bato and Bicol River, Luzon.

SILURIDÆ

Genus **HITO** novum

Dentes maxillis pluriseriati setacei; dentes vomerini in vittam angustam transversam continuam dispositi; dentes unusquisque palatinus in maculum parvum; nares anteriores brevi-tubulatae, posteriores valvula claudendae; pinna dorsalis supra ventres parvi; pinna analis caudali haud unita; pinna caudalis biloba; cirri 4; branchiost. 12-14; D. 4-3; A. 57-61; P. I. 11; V. 7.

35. taytayensis sp. nov., type of the genus; Taytay, Palawan.

Genus **PENESILURUS** novum

Dentes maxillis pluriseriati setacei; dentes vomerini in vittam angustam transversam continuam dispositi; dentes palatini in maculae parvi; nares anteriores pauci-tubulatae, posteriores valvulae parvi margini anteriores; pinna dorsalis rudimentaria, ante ventres parvi; pinna analis caudali haud unita; cirri 6, supramaxillares 2, inframaxillares 4; branchiost. 10; D. 2; A. 55; P. I. 11; V. 6.

36. palavanensis sp. nov.; type of the genus; Lake Manguao, Palawan.

ILLUSTRATIONS

PLATE 1

Trichogaster trichopterum (Pallas). Drawn by T. S. Espinosa from one of the type series of *Osphromenus insulatus* Seale; about × 2.

PLATE 2

FIG. 1. *Anabas testudineus* (Bloch); × 1. Drawn by M. Ligaya.
2. *Ophicephalus striatus* Bloch; × 1. Drawn by M. Ligaya.

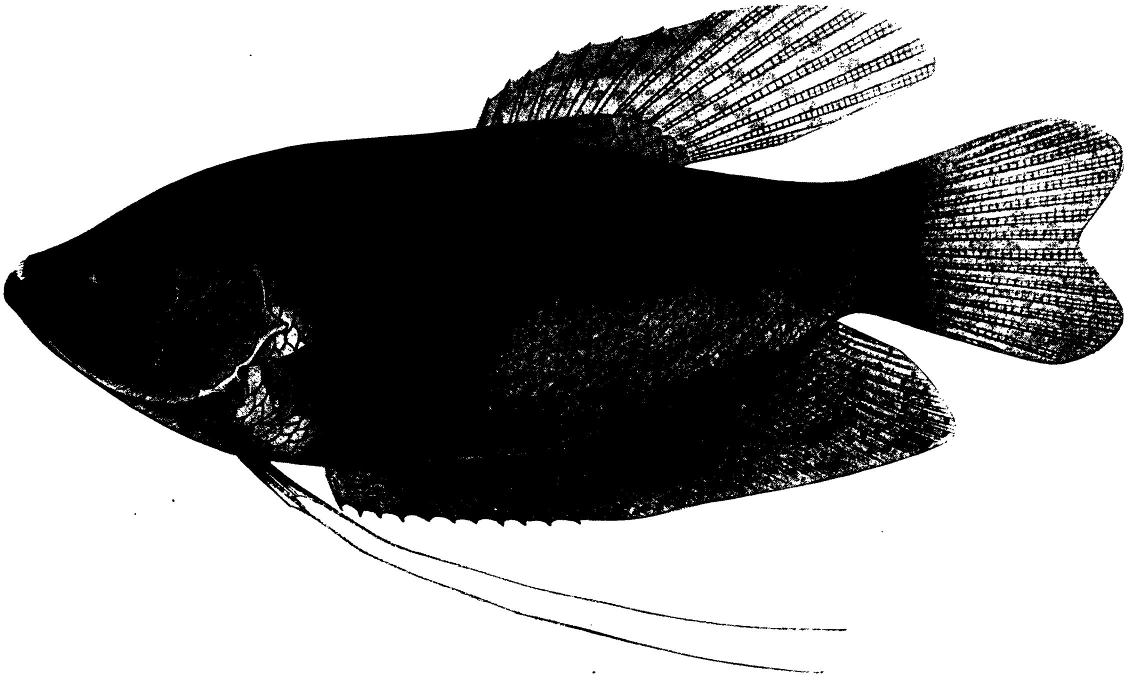

PLATE 1. TRICHOGASTER TRICHOPTERUM (PALLAS).

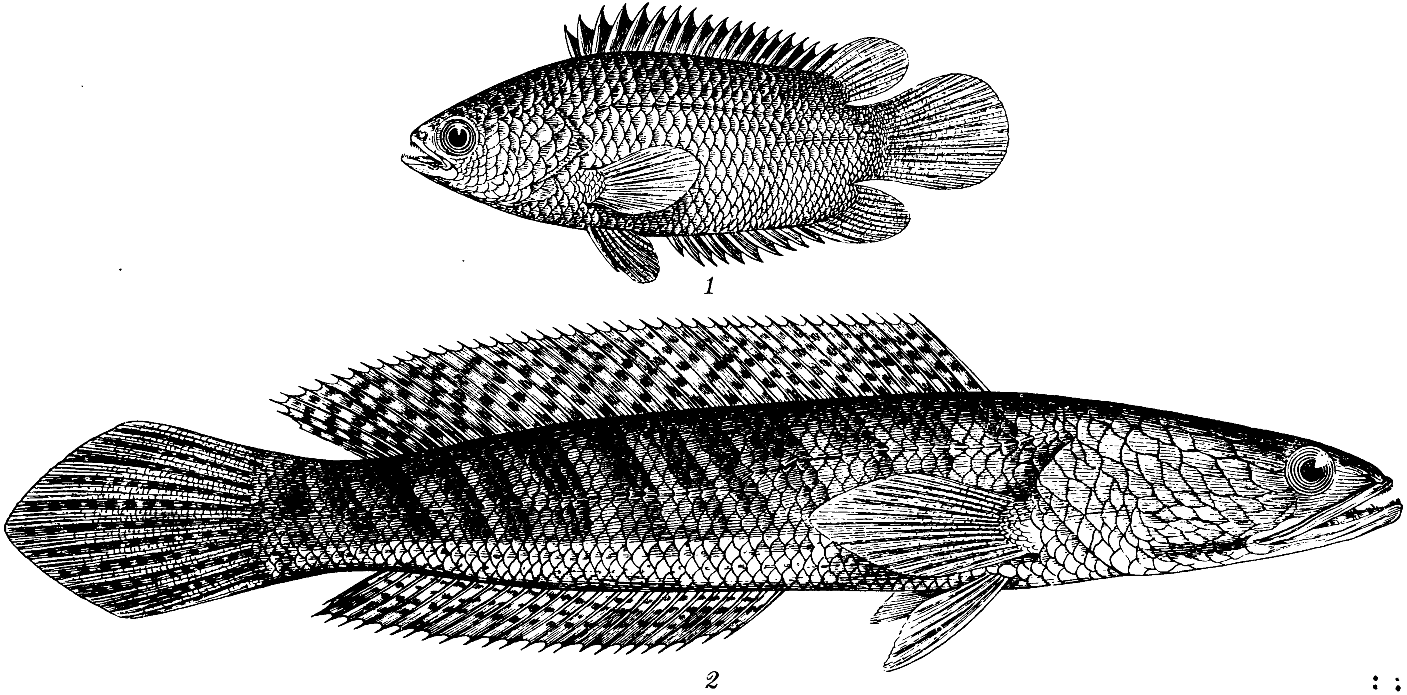

PLATE 2.

SOME APHIDIDÆ FROM THE FAR EAST

By Ryoichi Takahashi

Of the Department of Agriculture, Government Research Institute, Formosa

The aphids recorded in the present paper have been received from various sources. The Sakhalin specimens were collected by Prof. T. Esaki; the Korean material, by Mr. S. Muramatsu; the Manchurian, by Mr. Y. Yamada; and the Chinese, by Prof. Chen Shi-san, of the University at Nanking and by Mr. T. Nakajima in Amoy. The Japanese species are either from material sent in by Mr. M. Kurisaki or from my own collection. Grateful acknowledgment is due the above-named collectors who have contributed specimens.

The present records of aphid species are of particular interest in that practically nothing is known about this group of insects from those localities. The aphid fauna of North China, including Mongolia and Manchuria, and that of Korea and Sakhalin are absolutely untouched. Only a few species from Siberia have been recorded by Mordwilko, and nine from South China, by Lichtenstein and by Van der Goot.

Macrosiphum rudbeckiæ (Fitch).

Aphis rudbeckiæ Fitch, Cat. Homop. N. Y. (1851) 66; Essig, Pomona Coll. Journ. Ent. 3 (1911) 400.

Siphonophora rudbeckiæ Thomas, Illinois State Lab. Nat. Hist. Bull. 2 (1878) 4; Oestlund, Geol. Nat. Hist. Survey, Minnesota (1886) 20.

Nectarophora rudbeckiæ Oestlund, Geol. Nat. Hist. Survey, Minnesota, Bull. 4 (1887) 85.

Macrosiphum rudbeckiæ Davidson, Journ. Econ. Ent. 7 (1914) 136; Essig and Kuwana, Proc. Calif. Acad. Sci. 8 (1918) 52; Swain, Univ. Calif. Pub., Technical Bull. 3 (1919) 67; Patch, Maine Agr. Exp. Sta. Bull. 282 (1919) 218.

Host.—Unknown in Sakhalin.

Distribution.—Japan, Tokyo; Sakhalin, Toyohara; North America. Hitherto unrecorded from Sakhalin.

A winged and some wingless viviparous females were collected by Prof. T. Esaki at Toyohara, Sakhalin, in July, 1922. The specimens from Sakhalin agree in all taxonomic characters with those from Japan.

Macrosiphum rosæ (Linn.).

A few viviparous females were collected on *Rosa* sp. by Mr. T. Nakajima at Amoy, China, in June, 1923. Hitherto unrecorded from China.

Rhopalosiphum pseudobrassicæ (Davis).

Aphis pseudobrassicæ DAVIS, Canad. Ent. 46 (1914) 231.

Rhopalosiphum pseudobrassicæ TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 33; part 2 (1923) 91.

Host.—*Brassica oleracea* Linn.

Distribution.—Formosa, Japan, China, India, Java, Africa, North America. Hitherto unrecorded from China.

Collected by Prof. Chen Shi-san and sent to me for identification.

Aphis rumicis Linn.

Aphis rumicis TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 47; part 2 (1923) 101.

Host—*Rumex* sp.

Distribution.—Formosa, Japan, Sakhalin, India, Africa, Europe, North America. Hitherto unrecorded from Sakhalin.

A winged and numerous wingless viviparous females were collected by Professor Esaki at Toyohara, Sakhalin, in July, 1922.

Aphis gossypii Glov.

Some viviparous females were collected by Mr. T. Nakajima on *Colocasia antiquorum* Schott at Amoy, China, in June, 1923. Hitherto unrecorded from China.

Toxoptera leonuri Takah.[1] is an abnormal form of *A. gossypii* Glov. and must therefore be considered as a synonym of the latter. Some winged viviparous females, the third obliques of which are twice forked, and wingless ones were collected on *Leonurus sibiricus* Linn., on April 8, 1923, at Tansui, Formosa.

Aphis odinæ Van der Goot.

Longiunguis odinæ VAN DER GOOT, Contrib. Faun. Ind. Neerland. 1 (1917) 113.

Aphis somei ESSIG and KUWANA, Proc. Calif. Acad. Sci. IV 8 (1918) 75; TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 58; part 2 (1923) 110.

Host.—*Sapium sebiferum* Roxb.

Distribution.—Japan, Formosa, Java, China. Hitherto unrecorded from China.

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[1] Aphididæ of Formosa, part 1 (1921) 41; part 2 (1923) 94.

Some vivaparous females were collected by Mr. T. Nakajima on the plant mentioned above, on June 26, 1923, at Amoy, China.

? **Aphis malvoides** Van der Goot.

Aphis malvoides VAN DER GOOT, Contrib. Faun. Ind. Neerland. 1 (1917) 96; TAKAHASHI, Aphididæ of Formosa, part 2 (1923) 37 and 103.

Host.—*Bidens pilosa* Linn.

Distribution.—Formosa, China, Java, Singapore. Hitherto unrecorded from China.

Some specimens were collected by Mr. T. Nakajima at Amoy, China, in June, 1923.

Myzocallis querciformosanus Takah.

Myzocallis querciformosanus TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 72; part 2 (1923) 120.

Winged viviparous female.—Length of body, about 1.5 millimeters; antennæ, about 1.9; forewings, about 2. White. Antennæ white; dusky at apices of joints. Wings hyaline, slightly clouded along veins. Cornicles and cauda white. Legs white, with dusky tarsi. Dorsal tubercles white. Body oblong, soft. Head between antennæ provided with three pairs of very long, capitate hairs, arising from small tubercles, and almost as long as antennal segments I and II together. Frontal tubercles very short. Eyes large, protruding, with ocular tubercles. Antennæ longer than body, slender; segment I larger than II, convex on ental margin, and provided with a moderately long, capitate hair, as in II; III somewhat imbricated on distal half; basal half with four or five circular, medium-sized or large sensoria which are arranged in a single row and with two or three capitate hairs, which are shorter than those on basal segments; IV with neither sensoria nor distinct hairs; approximate relative lengths of antennal segments: III, 105; IV, 70; V, 70; VI, 120 (35 + 85). Rostrum almost reaching middle coxæ. Pronotum with a pair of long, capitate hairs which are as long as, or shorter than, those on anteromesal border of mesonotum; a pair of fingerlike tubercles, which are smaller than those on abdomen, near hind margin. Mesonotum with about ten long, capitate hairs of variable lengths and generally shorter than those on front of head. Abdomen provided with a few moderately long bristles on sternites, but not on tergites; three pairs of fingerlike tubercles on subbasal tergites; anterior two pairs of tubercles subequal in diameter to and slightly shorter than posterior; capitate hairs, which are almost equal in length to similar structures on front of head, on subapical parts of tubercles; four small blunt lateral tubercles, in front of cornicles, of which the posterior one is largest but shorter than cornicle; all tubercles provided with a few capitate hairs; another small blunt tubercle, which is provided with a pair of short hairs, anterior to cauda. Wings not wide; pterostigma with five long, somewhat knobbed hairs; stigmatic vein faint, almost obsolete; third oblique reaching apex of wing. Hind wings with two subparallel obliques; hooklets, two or three. Cornicles shorter than hind tarsi, longer than wide, expanded at base, not reticulated. Anal plate bilobed, with a few very long bristles. Cauda constricted basally, with a few very long bristles. Legs long and slender, furnished with many long capitate as well as normal hairs; tarsi with many minute spinules; hind tarsi almost as long as basal part of last antennal segment.

Host.—*Quercus dentata* Thunb., leaf.

Distribution.—Formosa; Japan. Hitherto unrecorded from Japan.

The Japanese specimens differ somewhat from the Formosan, but they seem to agree in sufficient characters to warrant their being placed in the same species. The foregoing description was based on specimens collected by me on June 6, 1923, at Oi in Gifu Prefecture, Japan.

In the original description I erroneously characterized the dorsal surface of the abdomen as being provided with many moderately long hairs and the antennæ as 0.95 millimeter in length. These mistakes are corrected here.

Shivaphis celti Das.

Shivaphis celti DAS, Memoirs Indian Mus. 6 (1918) 246; TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 74; part 2 (1923) 131.

Host.—*Celtis* spp.

Distribution.—Formosa, China, India, Ceylon. Hitherto unrecorded from China.

Collected by Mr. T. Nakajima at Amoy, China, in June, 1923.

Chaitophorus salijaponica Essig and Kuwana.

Chaitophorus salijaponica ESSIG and KUWANA, Proc. Calif. Acad. Sci. IV 8 (1918) 84.

Host.—*Salix multinervis* Doell.

Distribution.—Japan, Sakhalin. Hitherto unrecorded from Sakhalin.

Mr. Esaki collected a winged and three wingless viviparous females from an unidentified plant at Toyohara, Sakhalin, in

July, 1922. This species is allied to *Chaitophorus populi* Linn. and *C. viminalis* Monell, especially with respect to the granular dorsal surface of the wingless viviparous female.

Genus **KURISAKIA** novum

Winged viviparous female.—Body provided with numerous fine, long hairs. Head without frontal tubercles. Eyes with ocular tubercles. Antennæ five-segmented, with many minute spinules and fine, long hairs; sensoria subcircular or oval, spur of segment V much shorter than base. Dorsal tubercles absent. Front wings with third oblique only once forked; hind wings with only one oblique. Cornicles very short, wider than long. Cauda short, wider than long, not constricted at base, rounded. Anal plate rounded. Legs normal.

Genotype, *Kurisakia juglandicola* sp. nov.

This genus differs from other genera of the tribe Callipterina in the five-jointed antennæ, as well as in the character of wing veins.

Kurisakia juglandicola sp. nov.

Winged viviparous female.—Length of body, about 2 millimeters; antennæ, about 0.95; forewings, about 2.75. Body oblong, furnished with many fine, long hairs. Head with a median line. Frontal tubercles absent. Eyes moderate in size, with distinct ocular tubercles. Antennæ not imbricated, provided with numerous minute spinules and some fine, long hairs, five-segmented; segment I almost as long as II; III provided with about fourteen oval or subcircular sensoria of medium or rather large size, arranged in a single row almost the entire length, with many fine, long hairs; IV with about ten fine, long hairs, sensorium on apex of medium or rather small size, somewhat protruding, like the sensoria on III, not surrounded by hairs; relative lengths of segments: III, 97; IV, 32; V, 44 (36 + 8). Rostrum almost reaching middle coxæ. Body without lateral and dorsal tubercles. Subcosta of forewing provided with a few fine hairs arranged sublinearly; first and second obliques slightly curved, stouter than other veins; third, only once forked, obsolete at base; pterostigma normal; stigmatic vein not obsolete, nearly reaching apex of wing. Hind wings with only one oblique; hooklets, five. Cornicles large, but very short, wider than long, expanded basally, not constricted and not reticulated, with a few long hairs. Cauda wider than long, not constricted, rounded, hairy. Anal plate rounded. Legs provided with numerous minute spinules and many fine, long hairs; front tibiæ slightly stouter than antennal segment III; hind tarsi almost as long as base of terminal antennal segment.

Host.—*Juglans sieboldiana* Maxim.

Distribution.—Japan, Tadono, Wakayama Prefecture.

A few winged viviparous females and their nymphs were collected by Mr. M. Kurisaki on May 6, 1920. The collector furnished the following data: This aphis is found on the nether surface of the leaves. The wings are carried horizontally when at rest. The general color of the adults is yellowish green.

Dilachnus quercihabitans sp. nov.

Winged viviparous female.—Length of body, about 6 millimeters; antennæ, about 2.5; forewings, about 11; width, about 3.5. Head and pronotum blackish brown. Antennæ, eyes, and mesothorax almost black. Abdomen pale brown, with some very small and numerous minute dark brown spots on dorsum; lateral margins of last abdominal tergite and sternite dark brown. Cornicles dark brown. Cauda brown, more darkly so on posterior margin. Wings hyaline; pterostigma and subcosta dark brown; obliques yellowish brown. Legs mostly black, brownish basally. (Color notes based on specimens preserved in alcohol.) Body elongate, provided with many fine, long hairs. Head divided. Eyes prominent, with very small ocular tubercles. Antennæ relatively slender, provided with numerous very long hairs; segment I almost as long as hairs on front of head; III provided with about twelve to fourteen large, circular, protuberant sensoria, arranged in a row over entire length, except at basal fourth or fifth; IV with four to six similar sensoria mostly on distal half; V with three or four similar sensoria on distal half; VI with six to eight very small sensoria in a group near sensorium; approximate relative lengths of segments: III, 59; IV, 28; V, 30; VI, 20. Rostrum slender, reaching far beyond hind coxæ. Wings long, very delicate; pterostigma long, not reaching apex of wing; first oblique straight; second, slightly curved; third, faint, twice forked; stigmatic vein scarcely curved, reaching apex of wing. Hind wings with two divergent obliques; hooklets, six. Cornicles very short, on hairy cones. Cauda short, broadly rounded, almost semicircular from dorsal aspect; provided with numerous very long hairs. Legs very long and slender, covered with numerous very long fine hairs; tarsi long; hind tarsi longer than fifth antennal segment, first tarsal segment almost as long as claw, second almost three times as long as first.

Host.—*Quercus serrata* Thunb.

Distribution.—Korea.

Many winged viviparous females and their nymphs were collected by Mr. S. Muramatsu at Suigen, Korea, in May, 1920.

Cotypes in my collection.

? Tetraneura fusiformis Matsumara.

? *Tetraneura fusiformis* MATSUMARA, Essays for Nawa (1917) 74.

Host.—*Ulmus* sp.

Distribution.—Japan, Sapporo, Oita Prefecture; Manchuria, Koshurei. Hitherto unrecorded from Manchuria.

Many winged viviparous females, probably sexuparæ, were collected by Mr. Y. Yamada at Koshurei on October 2, 1918. These specimens exactly agree in taxonomic characters with those from Japan.

The present species differs from *Tetraneura ulmi* De Geer in the following points:

Approximate relative lengths of antennal segments: III, 66; IV, 20; V, 53; VI, 15.

Approximate distribution of antennal sensoria: III, 14 to 17; IV, 3 to 4; V, 12 to 14; VI, 1.

Tetraneura yezoensis Matsumara is undoubtedly a synonym of *T. ulmi* De Geer.

Aleurodaphis blumeæ Van der Goot.

Aleurodaphis blumeæ VAN DER GOOT, Contrib. Faun. Ind. Neerland. 1 (1918) 240; TAKAHASHI, Aphididæ of Formosa, part 1 (1921) 92; part 2 (1923) 150.

Astegopteryx japonica TAKAHASHI, Aphididæ of Formosa, part 2 (1923) 67 and 150.

Host.—*Blumea* sp.?

Distribution.—Japan, Tokyo; Formosa, Taihoku; Java.

Some wingless viviparous females were collected by me at Ikegami, Tokyo, on June 14, 1923. These specimens exactly agree in taxonomic characters with those from Formosa. The winged form of this species was erroneously described as *Astegopteryx japonica* sp. nov. by Takahashi.[2] The latter name is, therefore, a synonym of *A. blumeæ* Van der Goot. The winged individuals of the genus *Aleurodaphis* do not differ from those of the genus *Astegopteryx* in taxonomically important characters. In Formosa no winged form has been found.

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[2] Aphididæ of Formosa, part 2 (1923) 67 and 150.

DRY ROT OF CITRUS FRUITS CAUSED BY A NEMATOSPORA SPECIES

By H. ATHERTON LEE
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TWO PLATES AND ONE TEXT FIGURE

INTRODUCTION

There occurs in China, Japan, and the Philippines a peculiar condition of citrus fruits which considerably injures their texture, juiciness, and flavor. Philippine growers have frequently called this trouble to my attention and have experienced considerable losses on sales of such fruit. The disease has also been noted from Barbados in the West Indies by Nowell.(4) Work has been undertaken on this disease in the Philippines; not as a main project but as a problem to turn to whenever directly authorized projects would permit. Although time has not permitted an exhaustive study, this paper presents a description of the disease, some work indicating its cause, a description of the interesting causal fungus, and a possible method of prevention. By pointing out the seriousness of the disease in the eastern countries, it is also hoped to forewarn American citrus growers and research men so that its entrance into the United States can be prevented by enforcement of quarantine and inspection regulations.

DESCRIPTION OF THE DISEASE

The disease affects only the fruits and is not known to affect in any way other parts of the tree. The fruits show no symptoms of the disease externally; color develops normally; the affected fruits are neither harder nor softer than normal fruits. A normal citrus fruit contains from five to about fourteen section walls which are really a development from the outer skin; from these section walls and the outer skin arise the vesicles, which are of the nature of plant hairs although very much specialized, and these are usually turgid with juice. The vascular system coming through the stem of the fruit passes through the skin and section walls to feed the vesicles. Cutting into a fruit from the Philippines or from China or Japan, an abnormal condition is often evidenced by the thickness of the section walls, as shown in Plate 2. The section walls appear of a mealy texture, white, and as if dividing into separate membranes. Sometimes, however, the early stages of the disease will be evidenced by the condition of the flesh which has the appearance of being dry and brittle. The individual vesicles in such cases separate easily from each other and, according to the advance of the disease, are more or less dry and free of juice. As the drying advances the vesicles become wrinkled, atrophied, and entirely separated from each other, as shown in Plate 1. A section of such a brittle, dried vesicle shows the walls to have become considerably thicker than the wall of a normal vesicle. In advanced stages of the disease the vesicles have an even greater degree of inspissation and are entirely devoid of juice.

The fruits in the early stages have an unpleasant sourish taste, but in advanced cases become dry and almost entirely tasteless. The brittle manner with which the flesh crunches when chewed suggests very much the brittleness of a cabbage.

The disease sometimes is found to be confined entirely to one or two sections of the fruit, the remaining sections being entirely normal, as shown in some of the fruits illustrated in Plate 2. Just as frequently, however, the whole fruit exhibits this drying up condition. In very bad cases the normal semblance of the flesh is entirely lost and the section or the whole fruit becomes a mass of almost dried stringy vesicles sometimes of a deeper orange color than the normal flesh. There is never any blackening, and in but few cases does putrefaction follow. The name dry rot has been used in connection with this disease and, although there are grounds for criticism of such a name, after careful consideration it has seemed the most appropriate for popular use.

ECONOMIC SERIOUSNESS OF THE DISEASE AND ITS DISTRIBUTION

The initial loss caused by this disease is to the consumer, who buys the fruit as a good orange judged by its external appearance but upon eating finds it dry and tasteless and devoid of juice. The loss will sooner or later, however, ultimately be felt by the retailer, the wholesaler and, finally, the grower. In the Philippines the growers, having produced a crop of fruits more or less affected by the disease one year, find it hard to dispose of their crop the following year. The effect would probably be the same in other countries should the disease become established there.

Dry rot is very common in Batangas Province, which is the chief orange-producing section of the Philippine Islands. It has also, however, been reported from many other sections and is probably universally distributed in the Philippines. In China the disease has been seen commonly in the Canton delta, in the Swatow delta, at Amoy, and at Foochow. Affected fruits have been seen in Japan, but there is not enough evidence to enable one to know just how serious the disease is in that country. Foochow is well toward the northern limits of citrus fruit growing in China and there is little probability, therefore, that the temperature of either California or Florida would be a limiting factor in this disease. The disease was not seen in Java although the observations were limited.

The disease in the Philippines is very serious one year and will be scarcely noticeable for several successive years. Apparently seasonal conditions have an important influence on its occurrence. Peglion(6) notes the same variation in the occurrence of the *Nematospora* disease of hazelnuts.

HOSTS AFFECTED

Dry rot has been found upon fruits of the sweet orange (*Citrus sinensis*), the mandarin orange (*C. nobilis*), the calamondin (*C. mitis*), and the sour orange (*C. aurantium*). It has not been observed upon fruits of the grapefruit or pummelo (*C. maxima*), the lemon (*C. limonia*), the lime (*C. aurantifolia*), or the cabuyao (*C. hystrix*). In the case of the last-named three species the lack of a positive observation does not necessarily mean that they are nonsusceptible, since these species are not commercially grown to any extent in oriental countries and so opportunities for observation have been few. In the case of the pummelo (*C. maxima*) apparently there is some slight resistance to the disease; many of these fruits are produced in eastern countries, but I have never observed dry rot upon that host.

CAUSE OF THE DISEASE

Examination of vesicles from diseased tissue reveals almost uniformly yeast cells, and in many cases long slender spores. Isolation plantings have been made from bits of the diseased tissue, upon nutrient media in Petri dishes; such isolations have yielded a growth of the yeast with the nemalike spores in more than 95 per cent of the isolation attempts. Over two hundred such isolation attempts have been made. The growth from the early stages of the disease is usually a pure culture.

Inoculation studies, when undertaken in Philippine orchards, were at first almost entirely unsuccessful, due mainly to the rapid infection of the ripe citrus fruits with secondary fungi under the tropical conditions when needle punctures were made. Therefore, an attempt was made to coat the whole fruits with an infusion of the yeast cells, trusting to chance insect punctures to bring about infection. Another possibility that infection might take place at the stem end of the fruits also seemed plausible. Table 1 shows the first series of inoculations which had any significance.

The yeast cells with the nemalike spores were reisolated from inoculated fruits, both under the microscope and in culture. The conclusions from these inoculation tests are fairly well expressed in the following extracts from the field notebook:

> The most noticeable evidence from these inoculation experiments is that all the young green fruits remained negative, controlled fruits and inoculated fruits alike. Apparently then only the large, more nearly mature fruits are susceptible.

A year later, on my return to the Philippines, inoculations were made with cultures of the yeast reisolated from the positive results of the earlier inoculation series. The results of these tests are summarized in Table 2. Such inoculated fruits, whether in the orchard or in moist chambers, were first immersed in alcohol and dried, and inoculations by puncture were made always with a flamed needle.

To summarize the results shown in Table 2, 50 fruits punctured with a sterile needle and sterile water showed 8 positive cases of dry rot, or 16 per cent. The results from 82 fruits inoculated with a sterile needle and pure culture of the dry rot organism gave 48 positive cases, or 51 per cent. The following extracts from the field notebook give the conclusions drawn from the results at the time:

> The experimental results to support the view that the causal organism is the yeast are not the clear-cut data which are desirable. The difficulty lies in the fact that susceptible mature fruits in nature show such a high percentage of disease cases and that secondary rots cloud the results of inoculations by puncture. The evidence then must lie in obtaining a higher percentage of disease cases in the inoculated fruits than in the controls and this result has been obtained repeatedly as the data show.

TABLE 1.—*Summary of results of inoculations with yeast infusion on citrus fruits of different ages under orchard conditions.*

Character of fruits inoculated.	Inoculum of distilled water.		Inoculum of infusion of yeast cells.		Date of—	
	Fruits inoculated.	Positive infections.	Fruits inoculated.	Positive infections.	Inoculation.	Examination.
		Per cent.		*Per cent.*		
Calamondin fruits, all degrees of maturity; no punctures	10	10	10	40	October 24, 1918	November 26, 1918.
Small green calamondin fruits; no punctures	10	0	10	0	December 4, 1918	December 31, 1918.
Large green calamondin fruits; no punctures	10	10	10	40	do	Do.
Large ripe calamondin fruits; no punctures	20	35	10	90	do	Do.

TABLE 2.—*Results of inoculations with yeast organism on citrus fruits under orchard and laboratory conditions.*[a]

Character of fruits inoculated.	Method of inoculation.	Fruits inoculated.	Positive results.	Date of inoculation.	Date of results.
			Per cent.		
Large calamondins in orchard	Punctured with sterile water and needle	10	20	February 26, 1920	March 10, 1920.
Do	Punctured with needle and infusion of yeast	20	35	do	Do.
Do	Not punctured but immersed in yeast infusion.	10	0	do	Do.
Ripe calamondins in orchard	One needle puncture and pure culture of yeast.	10	60	do	Do.
Ripe daidai[b] fruits in orchard	do	10	90	do	Do.
Ripe daidai fruits in moist chamber	One needle puncture with sterile water	5	[c] 20	June 5, 1920	August 8, 1920.
Do	One needle puncture and infusion of yeast cells.	5	[c] 100	do	Do.
Do	Needle puncture with sterile water	10	30	August 28, 1920	September 20, 1920.
Do	Needle puncture with yeast culture	12	50	do	Do.
Do	Needle puncture with sterile water	9	22	October 5, 1920	November 29, 1920.
Do	Needle puncture with yeast culture	10	70	do	Do.
Do	Needle puncture with sterile water	11	0	May 6, 1921	June 1, 1921.
Do	Needle puncture with yeast culture	10	[c] 70	do	Do.
Batangas mandarin oranges in moist chamber	Needle puncture with sterile water	5	0	March 11, 1921	March 22, 1921.
Do	Needle puncture with yeast culture	5	[c] 20	do	Do.

[a] I was assisted in making these inoculations by Mr. Mariano G. Medalla, assistant pathologist of the Bureau of Agriculture, to whom credit and thanks are due.

[b] Daidai is the Japanese name for a sour orange of the Seville type, *Citrus aurantium*.

[c] Fungus recovered from each positive case, either under microscope or in culture.

It is rather reassuring also that whenever the disease is found in the controls the organism can usually be shown to be present by microscopic examination or by isolation in culture.

The constant isolation of this yeast in culture probably from 150 naturally occurring diseased fruits, obtained in a number of different conditions and from widely separated districts, of course is also a strong corroboration of the inoculation results. Normal fruits show no traces of this organism.

In such pioneer work with limited time it has been difficult to secure the opportunity for even these preliminary tests; however, the importance of forewarning citrus growers and research men of this disease urges the publication of these preliminary tests.

DESCRIPTION AND IDENTITY OF THE FUNGUS

In culture and on slides from affected fruit tissue, no considerable mycelium has ever been observed, although occasional small bits of irregular-appearing hyphæ may sometimes be found. The only forms of the organism observed from fruits and from cultures are ordinary yeast cells; much larger, rounded cells; club-shaped bodies, such as shown in fig. 1; and sporangia and spores, also shown in fig. 1. The forms frequently may all be seen on one slide from affected orange tissue. The yeast cells are ellipsoidal, approaching spherical, but not distinctive. The large round cells and the club-shaped bodies are difficult of comprehension; the walls of these bodies are slightly thicker than the walls of the yeast cells or of the sporangia but, other than this and their peculiar shape, nothing can be said of these bodies. The sporangia and spores are very distinctive; what appear to be young, newly forming sporangia can be seen frequently, and apparently the sporangia are developed by the enlargement of a single cell, such as Nowell(2) described for his

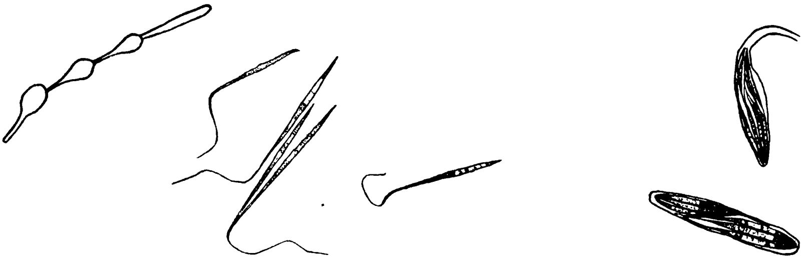

FIG. 1. The distinctive forms of the causal organism of dry rot. To the right, asci inclosing eight ascospores in two clusters of four spores each. To the left, the long, slender ascospores showing the thinning granulation toward the tips, the projection just below this thinning granulation, and the long appendages. To the left is one of the anomalous club-shaped bodies.

form D, and are thin-walled, hyaline, and elongate. Each sporangium observed contained two groups of four closely compacted spores; that is, eight spores to each sporangium.

The spores are extremely long and slender, narrowing gradually at one end into an extremely long appendage which has the appearance of a flagellum. The contents of the spores are rather densely granular and with a peculiar lessening of granulation in the upper half of the spore farthest from the appendage, as shown in fig. 1. Slightly above the middle of the spore, regarding the appendage as at the lower end, is a distinctive area of almost entire absence of granulation, which in some spores has the appearance of being a cell wall. It is not seen in the young, less-mature spores, and careful observation of many spores leads to the opinion that this is not a definite cell wall. A slight projection appears on each spore just below this area devoid of granulation, and this projection, the flagellumlike appendage, and the markedly lessened granulation in the upper end of the spore are the distinctive characters of the spores. All of these features are shown very definitely in fig. 1. These characters are seen readily in the spores without staining, but with carbol fuchsin or gentian violet are shown more clearly.

The spores are also shown in fig. 1, lying in the sporangium in characteristic position. The spores lie with their thinly granulated ends toward the extremities of the sporangia while the appendages from one group of four spores overlap the spores of the other group.

The sporangia are usually 75 to 110 by 6.5 to 20 micromillimeters in size, and the spores vary from 42 to 66 micromillimeters in length and are usually 1.5 to 3 millimeters at their greatest width. The appendages are from 11 to 40 micromillimeters in length. It is rather difficult to determine which point should be taken as the end of the spore and the beginning of the appendage.

The yeast cultures readily and makes a quick growth on nutrient beef agar and a very copious growth on potato cylinders. On agar plates the growth resembles that of bacterial colonies more than that of a fungus; growth is rapid at laboratory temperatures of 28° to 30° C., round to irregular, rather grayish or dirty white, raised to pulvinate, surface irregular and hummocked, edge entire, and internal structure granular. The colony is of an easily separated consistency, and there is no marked or characteristic odor.

Peglion(5) described a fungus as *Nematospora coryli* growing upon the hazelnut (*Corylus avellana*), which is very similar to the yeast on oranges. The original description has not been available to me, but a second paper by Peglion(6) describes the fungus completely and this paper has been available. The disease of hazelnuts is very similar in its pathological aspects to the disease of oranges reported here. In many cases, according to Peglion, the disease cannot be observed externally on the fruits of the hazel but is found only on breaking into the nut. The disease imparts a peculiar, disagreeable taste to the nut, but does not cause a putrid decay. Peglion found that the disease varied from year to year but never attacked less than 5 to 6 per cent of the nuts observed in the markets.

Concerning the fungus of the hazelnut disease, Peglion describes elongate, sharply pointed yeast cells, definite mycelium, thick-walled, irregular-shaped bodies which he called anomalous vegetative forms, and asci and ascospores. The asci are identical in character and shape with the sporangia of the citrus dry-rot fungus and contain the same number of long, needle-shaped spores with long appendages, arranged in the same order of two groups of four spores each. Peglion described his fungus as a new genus and species of the order Saccharomycetae, *Nematospora coryli*. The citrus dry-rot organism belongs quite naturally in this genus.

There are a few minor differences between the *Nematospora* of the citrus disease and *N. coryli* Peglion. Peglion's drawing shows the yeast cells of *Nematospora coryli* uniformly more elongate and sharply pointed than are the yeast cells of the orange dry-rot fungus. He also describes a very definite mycelium, which has not yet been observed in the citrus dry-rot fungus in the Philippines. Peglion did not describe thick-walled, club-shaped bodies such as are found in the cultures of the orange fungus, but described forms, very similar in structure but not in shape, as anomalous vegetative forms. The ascospores are very similar in both, being long, slender, and with long appendages, although the fungus from the hazelnut has spores which do not show the septumlike absence of granulation that is seen in the spores of the orange fungus. Peglion gives the dimensions of the spores of *N. coryli* as 38 to 40 by 2 to 3 μ and the flagella 35 to 40 μ in length, and the dimensions of the citrus fruit *Nematospora* are quite similar. In culture, however, there is also a marked difference, since the hazelnut fungus, according to Peglion, forms very distinct crateriform colonies on beef agar, while the fungus from citrus fruits forms very decided pulvinate colonies. It would seem that the *Nematospora* of the citrus disease is a species quite distinct from *N. coryli.*

It is of interest to note that Peglion inoculated his *Nematospora coryli* upon hazelnuts but, similarly to my first experiences in the Philippines, he had difficulty with other fungi causing decay. His belief, however, was to the effect that infection of the hazelnut took place while the fruit was young, and not toward maturity as is apparently the case in citrus fruits.

In 1916 Schneider(7) described a fungus, found upon a tomato from tropical regions, causing a pathological condition on the tomato very similar to the condition found on oranges in the Philippines. He described yeast cells very similar to those of the citrus dry-rot fungus, large round cells, and club-shaped bodies identical with those described here. The asci and ascospores of Schneider's fungus were, moreover, almost identical in shape and character with those of the Philippine citrus dry-rot fungus. The ascospores are slightly shorter and not so slender as the spores of the citrus fungus, although their appendages are longer. Schneider calls the large round cells of his fungus arthrospores, but I hesitate to apply this term to the round cells of the citrus dry-rot fungus. He also writes of gametic fusion processes which have not been observed as yet in the case of the citrus-fruit *Nematospora* in the Philippines. In a later paper Schneider(8) described the tomato fungus as *Nematospora lycopersici.* No cultures of the fungus were made, nor were inoculations attempted.

Nowell(3) has published an account of the internal boll disease of cotton in the West Indies which is characterized by a discoloration of the lint within the boll and a premature dropping, but the bolls show no external evidence of the disease whatsoever. The disease in its general character is very similar to the hazelnut disease of Peglion, the tomato disease of Schneider, and the citrus dry-rot disease in the Philippines here discussed. Nowell(2) has described four closely related fungus species associated with the internal boll disease of cotton, one of the fungi without question being a *Nematospora.* Insects which puncture the cotton bolls were suspected by various writers of causing the lint discoloration, but Nowell showed the presence of the fungi and, by careful bagging experiments, showed that the infection was brought about by insect punctures.

Nowell described his cotton-boll disease fungi as forms A, B, C, and D; form D consists of elliptical to ovoid yeast cells, large spherical cells similar to the arthrospores of Schneider, sporangia and spores very similar to those of Peglion's *Nematospora,* and definite mycelium formation. The spores of Nowell's form D are very similar in size to those of *N. coryli* and but slightly smaller than those of the Philippine citrus fungus. The citrus dry-rot fungus of the Philippines answers very closely to the description of Nowell's *Nematospora,* with the exception that in the Philippines definite mycelium has not yet been observed in connection with the citrus dry-rot fungus. It is believed, however, that conditions and circumstances for the growth of the species could easily influence the presence or absence of the mycelium.

In a later short note, moreover, Nowell records the observation of his form D on oranges in Barbados causing a pathological condition similar to that found in the Philippines. He found insect punctures accompanying the disease on the orange also as well as on the cotton bolls. Therefore, identity of the citrus dry-rot *Nematospora* with Nowell's form D would seem to be quite definite. In as much as further work will possibly uncover considerably more knowledge of the morphology of the fungus, and since Nowell has already done much work on the problem, it would seem well to refrain from describing it as a new species in the present paper. For the present, reference to the fungus is easily possible by calling it the citrus dry-rot *Nematospora.*

Nowell does not regard the species of the genus *Nematospora* as ascomycetes, his view being based apparently upon the absence of gametic processes in these fungi. On the other hand Guillermond(1) states:

> The ascospores in certain yeasts present on the other hand characteristic forms absolutely analogous to the ascospores of certain Ascomycetes. Thus it is that ascospores of * * * and *Nematospora coryli* have forms which suggest very strongly those of certain Ascomycetes.

It would seem as if there were some justification, therefore, for holding for the present at least to a rather interesting placing of these fungi with the Saccharomycetae in the systematic arrangement.

PATHOLOGICAL HISTOLOGY

Opportunity has not been available for the exhaustive study which would be desirable for this phase of the disease. In the absence of insect studies it is only possible to conclude, from the analogy of citrus dry rot with internal boll disease of cotton, that insects are passive carriers of the *Nematospora* of citrus dry rot. This would possibly explain the absence of infection in the pummelo and grapefruit, since such fruits have very thick skins through which it would be difficult for an insect puncture to penetrate. It is noticeable also that the thin-skinned mandarin oranges and calamondins are abundantly infected while the sweet-orange fruits of the Philippines with thicker skins are much more rarely affected.

It is of interest to note also a chance finding of *Nematospora* spores on the bark of citrus trees. An examination under the microscope was made of scale insects being parasitized by fungi, and a scraping was unintentionally made of the bark of the host tree; several isolated *Nematospora* spores were observed in such scrapings, indicating widespread distribution and ready chances for infection.

Even when the organism has secured entrance into the pulp of the fruit the pathology is not entirely clear. Study of the cells of the tissues of the vesicle walls shows immense numbers of yeast cells present, but in no case have any such yeast cells been definitely shown within the host cells; they apparently exist between the vesicles and cells of the vesicles. Apparently such conditions are very favorable for the development of the organism and multiplication is very abundant. In the tissues the large round cells and yeast cells are predominant, while the asci and ascospores are present but not as abundant as in cultures.

Frequently in an affected fruit small white specks may be observed; under the microscope these are found to be masses of the fungus, usually all forms being present but the asci especially numerous. Such white masses of the organism in the tissues are one of the peculiar features of the disease, not uniformly present but still by no means rare.

It is also difficult to account for the drying up and inspissation of the tissue. Apparently the vascular system is not interfered with; examinations have been made with this particular point in view and no evidences of the organism in either phloem or xylem cells have been apparent. On the other hand, the cells of the vesicle walls are very much changed in pathological tissues. The walls are thickened, irregular in outline, and apparently disrupted in some cases. It would seem as if the growth of the yeast may result in by-products which bring about this effect on the cells and the resulting pathological condition.

SUGGESTIONS FOR CONTROL

At Lamao, Philippine Islands, spraying experiments against citrus canker were carried on in 1917 and 1918. In the beginning of these experiments fruits on trees in the sprayed plots were found to be badly affected by dry rot. Two trees of the sour orange (*Citrus aurantium*) are on record as having over 80 per cent of the fruits affected by dry rot. At the conclusion of the experiments the two trees, having been sprayed with Bordeaux 4–4–50 four times during the season, were found to have practically all fruits free from dry rot. The case is so confined as to be of little value, except as an indication that certain procedures of spraying might be successfully tried experimentally against dry rot. The effect of applications of fungicides to citrus trees would certainly lessen the number of disseminated *Nematospora* spores.

Control for the citrus-growing districts of the United States, of course, should consist in the entire exclusion of the fungus. For this reason rigid maintenance and enforcement of quarantine regulations should be practiced.

SUMMARY

A disease which attacks the fruits of citrus trees is described and the name dry rot is given to it. Dry rot destroys the desirable eating qualities of fruits and, once introduced into the United States, would cause considerable loss to the orange growers.

The disease has been found in the Philippine Islands, in China and Japan, and has been reported by Nowell from Barbados, in the West Indies. Its distribution precludes the possibility of temperature being a limiting factor in the development of the disease in the United States. The disease has been observed to affect the sweet orange, the mandarin orange, the sour orange, and the calamondin. No observations are available for the lemon, the lime, or the cabuyao. The pummelo is believed to have some degree of resistance to the disease. Preliminary experiments show the cause to be a yeast of the genus *Nematospora* of Peglion. The fungus is described but a much more complete comparative study is desirable before naming it as a new species.

Although spraying may prevent the disease, it is suggested that control for American growers lies in the prevention of the introduction of the disease into the United States, by rigid enforcement of quarantine regulations.

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ILLUSTRATIONS

PLATE 1

FIG. 1. A normal fruit of *Citrus aurantium.*

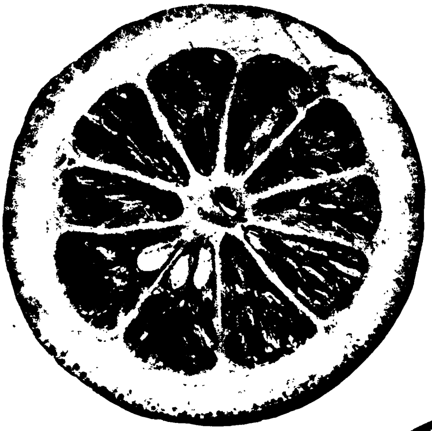
FIGS. 2 and 3. Two fruits of the same species affected with dry rot, showing thickened section walls and inspissated vesicles.

PLATE 2. CALAMONDIN FRUITS, CITRUS MITIS, AFFECTED WITH DRY ROT

FIG. 1. Early stages of infection showing thickened section walls.
2. Fruits showing advancing stages of the disease.

TEXT FIGURE

FIG. 1. The distinctive forms of the causal organism of dry rot. To the right, asci inclosing eight ascospores in two clusters of four spores each. To the left, the long, slender ascospores showing the thinning granulation toward the tips, the projection just below this thinning granulation, and the long appendages. To the left is one of the anomalous club-shaped bodies.



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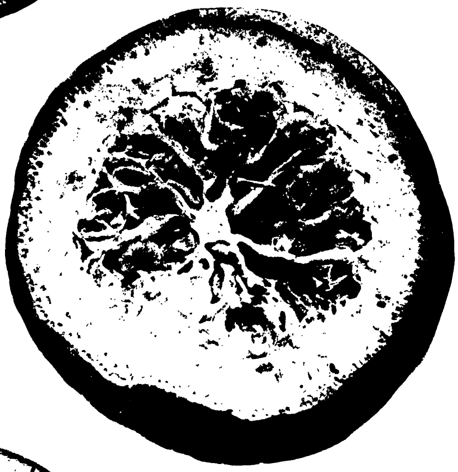

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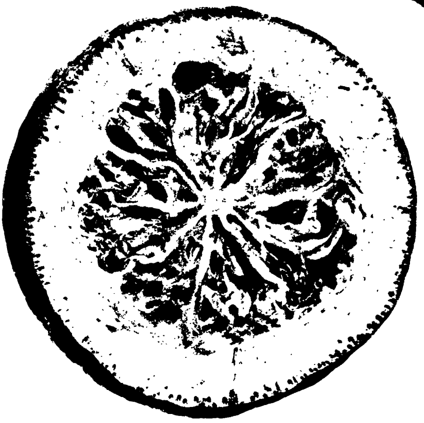

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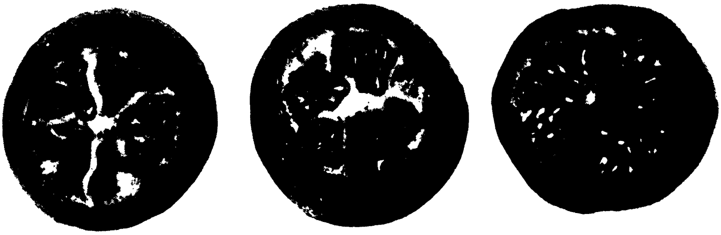
PLATE 1.



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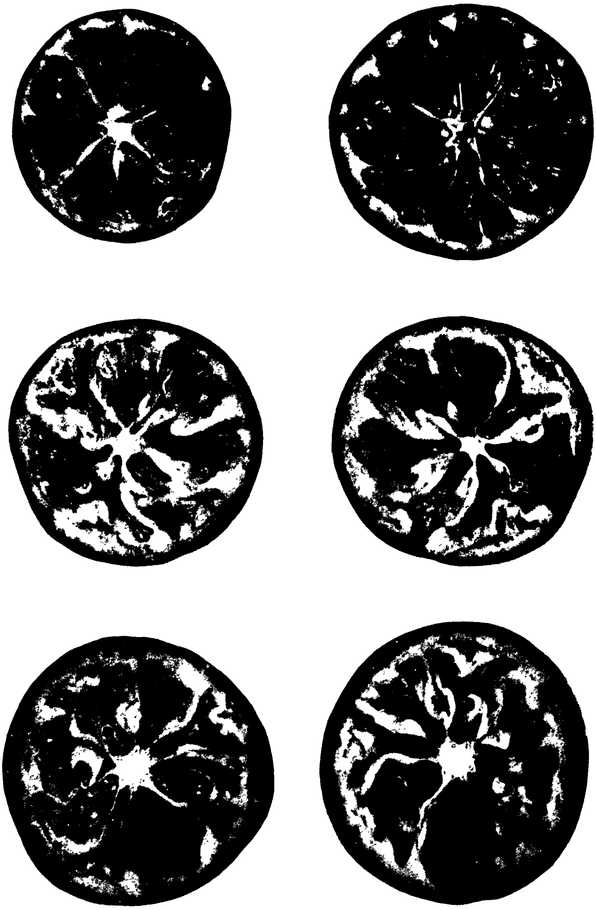

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PLATE 2.

BACTERIOLOGICAL EXAMINATION OF STOOLS OF FOOD HANDLERS IN MANILA

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and

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One of the greatest sanitary problems in the Philippines is that of controlling diseases of the intestinal tract. During the past there have been severe epidemics of cholera, typhoid fever, and dysentery. Cholera has been placed well under control, so that at the present time it is not a serious menace, but only requires scrupulous care to see that it does not again break out in the Islands. Typhoid fever and bacillary dysentery, on the other hand, are endemic and very frequently reach epidemic form. The control of these depends largely upon the ability of the Public Health Service to trace down the source of infection and to control the surroundings of the actual cases and the known carriers. Many of the reported epidemics of typhoid fever and dysentery have been traceable to some one definite source of origin. Some of these have been well-defined clinical cases, some mild or ambulatory cases, and still others carriers, all of whom have served as foci for epidemics either by direct contact with other persons or by their excreta contaminating the food and water supply of others. Schule [1] reports that in the area served by the German laboratory at Trier it was possible to determine the source of 67 per cent of the infections occurring in that area during 1918. Sixty per cent of the infections were due to contact with other cases, 5 per cent to contact with carriers, and 1 per cent each to infected milk and water.

At all times the food handler is looked upon with suspicion when an epidemic of intestinal disease arises. As a result of the prevalence of typhoid fever in Manila during the past year, we were called upon to examine the fæces of food and water handlers on a very large scale. Two groups of the personnel of the biological laboratory, Bureau of Science, were engaged almost exclusively in this work for a period of approximately six months.

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[1] Schule, Paul A., Military Surgeon **45** (1919) 268.

In so far as we were able to determine, all of the food handlers, whose stools were examined by us, were healthy persons. We would like therefore to emphasize the fact that when the term "food handler" is used in this report it refers only to healthy persons and does not refer to typhoid and dysentery patients nor to convalescents from either. We will refer in Table 2 to the examination of stools of patients and contacts, merely as a control on our technic.

COLLECTION OF STOOLS

At first the stools were collected at the various public-health stations in the city and were sent from there to the Bureau of Science, where they were cultured. This procedure involved of course a delay of several hours in some cases from the time the stool was passed until it was cultured. The consistently negative findings in these cases caused us to feel that the long delay in culturing the stools might be an important factor in producing the negative results. Arrangements were then made whereby one portion of the persons whose stools were to be examined were to come to the Bureau of Science and pass a stool while there, so that it might be cultured under the most favorable conditions. In a few instances of course this worked a hardship on the applicant who was unable to pass a stool and who had to return at a later date. We feel that the procedure was justified in view of the fact that we were able entirely to rule out the time factor. We were somewhat surprised to find that practically all stools examined under these favorable conditions were also negative for typhoid, paratyphoid, dysentery, cholera, and non-agglutinating vibrio. One of the bacteriological sections examined a total of 1,617 stools, approximately half of them by the first method of collection and the other half by the second method. A sufficient number was examined, therefore, to judge between the methods, had there been any difference in the results. A brief history was obtained from each person examined, the chief points of which were the person's age, occupation, place of occupation, residence, public-health district, and whether the person had received prophylactic inoculation with cholera and typhoid vaccine.

TECHNIC OF CULTURING

The technic generally used in these examinations was as follows: When the specimen was received a portion of the fæces was inoculated into nutrient broth, incubated for from three to five hours at 37° C., and then streaked on plates of Teague methylene blue eosin medium and litmus lactose agar, and some of the specimens were also streaked on Endo plates. They were allowed to incubate for from twelve to twenty-four hours, when they were examined for suspicious typhoid and dysentery colonies. When such colonies were found they were transferred to modified Russell's double sugar medium and microscopic agglutination tests were made. If the Russell's double sugar tubes were still suggestive of typhoid or dysentery, macroscopic agglutination tests were made and differential carbohydrate media were inoculated. For the detection of cholera and non-agglutinating vibrio, a small portion of the stool was emulsified in 5 to 7 cubic centimeters of the following medium: Ten grams peptone (Witte or Merk); 5 grams sodium chloride; 1,000 cubic centimeters tap water; adjusted to 0.5 per cent alkaline. The tube was incubated for from eighteen to twenty-four hours, examined for motility, and plated on Dieudonne medium. The plate was incubated for twenty-four hours and examined for suspicious colonies. These colonies were tested for motility, agglutinability, and staining qualities.

The results of the investigation by the first group are shown in Table 1.

TABLE 1.—*Stools examined by first group, April 24 to October 24, 1923.*

Public-Health District:	
No. 1	188
No. 2	47
No. 3	0
No. 4	281
No. 5	290
No. 6	811
Results:	
Positive [a]	2
Negative	1,615
Typhoid inoculations:	
Complete series	556
Two	135
One	772
None	154

[a] One of these two carriers was found positive twice, while the other has continued positive each week for a period of approximately five months.

One of the most interesting features brought out in this part of the investigation is the high percentage (approximately 90.5) of positive inoculations with cholera and typhoid vaccine. The complete series of injections had been given to 34.3 per cent; two injections, to 8.5 per cent; and one injection, to 47.7 per cent, leaving 9.5 per cent who had received none. It must be remembered that these figures were taken at a period when a special antityphoid campaign was being conducted. This speaks very highly for the efforts of the Public Health Service to control the typhoid situation.

The second group of workers did not confine themselves entirely to the examination of stools from food handlers, but received specimens also from a group of healthy persons taken at random, and from patients chiefly from San Lazaro Hospital and from persons who had been in direct contact with typhoid or dysentery cases. The number examined by this group was greater than that examined by the first group, but the data were less complete. The results will, therefore, be given in a separate table. Some of the stools examined by this group were from the same persons as were some of those examined by the preceding group, but they were collected at different times. The technic was the same in both groups.

Table 2 shows the results of the work performed by the second group.

TABLE 2.—*Stools examined by second group.*

Food handlers	3,184
Healthy persons selected at random	269
Patients of San Lazaro Hospital	816
Persons directly in contact with typhoid or dysentery cases	1,072
Convalescents	201
Total	5,542
Results: [a]	
Positive—	
Typhosus	19
Paratyphosus A	1
Dysenteriæ	22
Negative	5,500

[a] Food handlers and other healthy persons all negative. All positives were isolated from patients.

By referring to Table 2, it will be seen that the total number of those classed as food handlers, contacts, and healthy persons is 4,525, and that all of them were negative for typhoid, paratyphoid, dysentery, cholera, and non-agglutinating vibrio. Only a small portion of the 1,017 patients and convalescents were clinically positive for typhoid or dysentery, and from these typhoid bacillus was isolated nineteen times, paratyphoid A bacillus once, and dysentery (Shiga and Flexner) twenty-two times.

At the present time we are studying the urines of typhoid patients and convalescents to determine whether a larger percentage of positive cultures can be obtained from the urine than from the blood and fæces of the same patients.

Combining the results of the two groups, we have a total of 6,143 examinations of stools from apparently healthy people with only two positive for typhoid bacilli. Using the same technic for the examination of stools from patients, we obtained a reasonable number of cultures positive for typhoid and dysentery.

It is possible, of course, that the method of obtaining the stools might have been improved upon in two ways. First, the samples might have been more satisfactory had the applicants been given purgatives the night before the examinations were made. This would have insured a fluid stool and also one from higher in the intestinal canal. Since the majority of typhoid carriers are supposed to harbor the typhoid bacillus in the gall bladder, it appears theoretically that a method which would give a specimen of fæces from the upper portion of the intestines would be the method of choice.

The second, and perhaps the most important, improvement that could have been made in the collection of the stools would have been multiple examinations of the patients' stools; for example, an examination of the stools at least three times, with intervals of from three days to a week between examinations. It might be of interest to note at this point that, in a personal interview with the chief of the laboratory division of the United States Army, we were told that they had recently completed several thousand examinations of the stools of food handlers in the United States Army and that they found only one typhoid carrier in the number examined. This report is entirely in accord with our own findings in Manila.

As a matter of interest to those carrying on the work, the last 730 stools were examined microscopically for parasites and ova. The results of this feature of the work are shown in Table 3.

TABLE 3.—*Microscopic examination of stools for parasites and ova.*

Ascaris	428
Trichuris	338
Hookworm	109
Strongyloides	4
Oxyuris	3
Tænia	4
Lamblia intestinalis	2
Blastocystis	10
Entamœba	70
Single and multiple infections:	
Single	322
Double	246
Triple	54
Quadruple	6
Total:	
Positive	628
Negative	102

In these examinations three slides were prepared from each specimen; if they were all negative, the concentration method was used. It can be seen at a glance that the intestinal parasites are highly prevalent among this apparently healthy group of food and water handlers. Approximately 60 per cent show *Ascaris,* 46 per cent *Trichuris,* and 15 per cent hookworm. No doubt the hookworm incidence in Manila is much higher than is indicated by this limited number of examinations. Since we were interested primarily in the bacteriological phase of the problem, we shall let this portion of the report stand without further comment.

In conclusion, we would like to call attention to the fact that, in our examination of over 6,000 stools from food handlers and other healthy persons, the typhoid bacillus was isolated from but two persons, and that all were negative for dysentery, cholera, and non-agglutinating vibrio. This indicates to us that the wholesale examinations of single stools from food handlers in a city like Manila is not warranted. We do not wish to underestimate the fact which is generally known that the stool of a typhoid carrier may be negative on one examination and positive on the next. As a result of our findings and those referred to, in the United States Army, we would venture the opinion that at the present time the chronic carrier is not as serious a factor in the epidemiology of typhoid and dysentery as he has previously been considered to be. It is possible, however, that the large percentage of prophylactic inoculations with cholera and typhoid vaccine may and probably does reduce the number of carriers. The convalescent patient or temporary carrier, or the person who is suffering from a mild infection, or one who is in direct contact with an active typhoid or dysentery case, either of whom happens to be a food handler, creates a problem different from that of the average food handler and must be dealt with as the occasion arises. These individuals can only be detected by the combined efforts of the sanitarian and the bacteriologist.

NEW DYTISCIDÆ

By A. ZIMMERMANN
Of Munich, Germany

Gaurodytes philippensis sp. nov.

Length, 6.25 millimeters; width, 3.25. Subelongate oval, beneath black, epipleura and apices of ventral segments pale; palpi, antennæ, and the four anterior legs rufous, femora and tibiæ of hind legs piceous. Head and thorax blackish, not or faintly æneous, the former with clypeus and two obscure spots on vertex, the latter with the sides and sometimes also with the basal margin narrowly rufous. Elytra rufous, almost unicolorous, only on disk of posterior half very slightly infuscate.

The elytral reticulation is very minute and uniform throughout, without fine punctulation. The usual dorsal series of punctures fine, but behind considerably confused. Reticulation of thorax and head stronger, the meshes larger and unequal. Prosternal process rather small and convex before, feebly convex or flattened and slightly margined behind coxæ; the lateral wings of metasternum rather small. Protarsi and mesotarsi of male rather feebly dilated, protarsal claws simple, not longer than in female.

Probably a high-mountain species belonging to the *congener* group; it is very close to both *japonicus* Sharp and *æquabilis* Gschwendt but is quite distinct on account of its pale rufous elytra and smaller size. The reticulation of thorax and head is appreciably stronger and the meshes are rather larger.

LUZON, Benguet Subprovince, Mount Pulog (*McGregor*).

Described from four examples, 1 male and 1 female in my own collection, and 2 males in the collection of the Bureau of Science, Manila.

Gaurodytes bakeri sp. nov.

Length, 6.5 to 6.75 millimeters; width, 3.25 to 3.5. Extremely close to *philippensis,* but separable with certainty by the more oblong and subparallel form of body, which is scarcely enlarged in the middle. Head and thorax with rather distinct æneous luster, the pale side margins of the latter smaller, the elytra considerably more infuscate, the legs darker, the femora of the four anterior legs piceous, prosternal process behind coxæ a little broader.

LUZON, Benguet Subprovince, Baguio (*Baker*).

I have seen a considerable series, the greater number from the collection of Prof. C. F. Baker, Los Baños.

Hydaticus schultzei sp. nov.

Length, 11 to 11.5 millimeters; width, 6.25. Oblong-oval, rather feebly convex. Body shining, beneath piceous, the abdomen rufopiceous, the first four segments with a rufous spot on each side. Epipleura, prosternum, antennæ, palpi, and the four anterior legs rufous, swimming legs black. Head and thorax rufotestaceous, the former with a small black basal fascia and a rather broader band along the posterior half of the eyes, the latter with a broad median spot, which is enlarged before and behind. Elytra black, each with a very small side margin, a small subbasal fascia (reaching neither the suture nor the shoulder) and four well-isolated clear spots rufous; one of these forms an irregular semicircle on the shoulder, one is subapical, and of the two others a little behind the middle the inner is roundish, the outer rather oblique.

Reticulation very minute; over the upper surface minute punctules irregularly and sparingly distributed, a little stronger and denser on the head. On each side of thorax is a group of more distinct punctures and in the female there is also a large field of irregular very strong scratches.

In general aspect the new species resembles *macularis* Reg. from Palawan, but is quite surely distinct by the rufous color of head, thorax, and epipleura and by the much stronger sexual sculpture of the female.

PALAWAN, Taytay; Iwahig, Rio Quinina (*Schultze*).

A male and a female in my collection; a second male in the collection of the Bureau of Science, Manila.

THE PHILIPPINE SPECIES OF PAREVASPIS, A GENUS OF BEES

By H. L. VIERECK
Of Ottawa, Ontario, Canada

ONE TEXT FIGURE

If I have correctly correlated the sexes, then I have to report from the Philippine Islands at least two new species of this genus or subgenus. According to Reinhold Meyer's key[1] these species agree with *Parevaspis polynesia* Vachal and *P. strandi* Meyer in having the abdomen entirely red or reddish, but differ in the female in having the sixth sternite simple except for a central swelling.

Parevaspis bakeri sp. nov. Fig. 1, *a, b.*

Type.—Male, catalogue No. 26601, United States National Museum.

Allotype.—Female, catalogue No. 26601, United States National Museum.

Type locality.—Kolambugan, Mindanao (*Baker 17235*).

Male.—Length, 12 millimeters; front and vertex with coarse, deep, adjoining or nearly adjoining punctures but not everywhere as close together as possible, punctures of mesonotum not so coarse as on the front, the puncturation here more uniformly dense than on the front and vertex, scutel with larger, shallower punctures than the dorsulum, its punctures not so close together, scutel slightly indented at apex in the middle, the interstices of the puncturations elevated, scutel uniformly black like the rest of the thorax and the head, sixth and seventh sternites in outline as figured, fifth sternite with a median triangular tooth on its apical edge, hypopygium as figured.

Female.—Length, 16 millimeters; agrees with the male except for the secondary sexual characters. This female is from Surigao, Mindanao (*Baker 17232*).

Parevaspis impressus sp. nov. Fig. 1, *c, d.*

Type.—Male, catalogue No. 26602, United States National Museum.

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[1] Archiv für Naturgeschichte (1921).

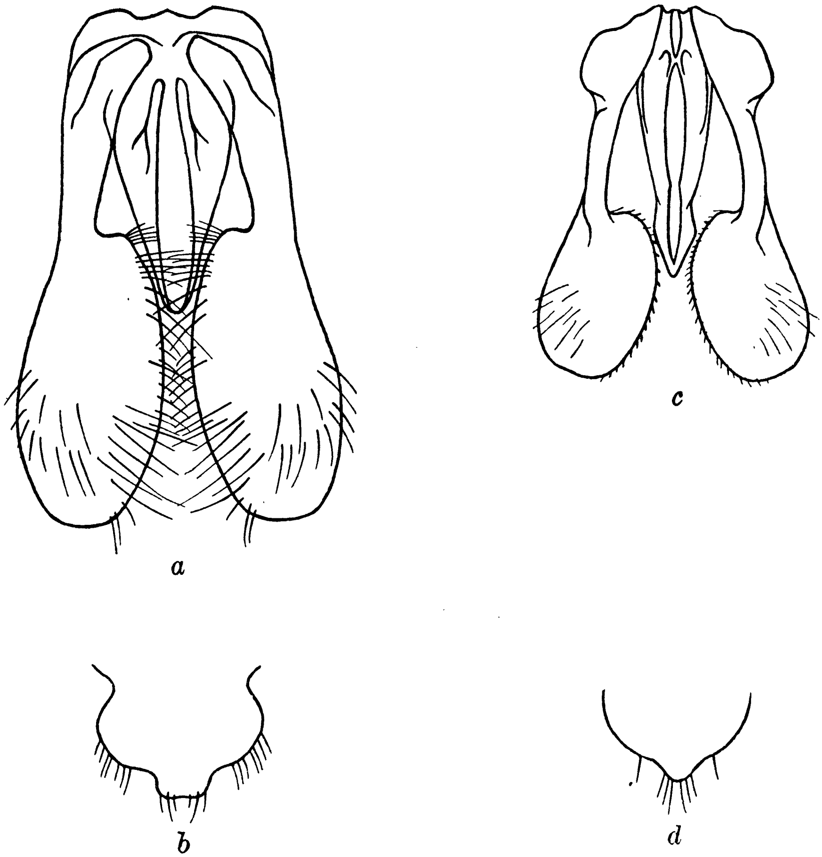

FIG. 1. *Parevaspis bakeri* sp. nov., male, *a*, hypopygium; *b*, seventh sternite. *Parevaspis impressus* sp. nov., male, *c*, hypopygium; *d*, seventh sternite.

Allotype.—Female, the same catalogue number.

Type locality.—Surigao, Mindanao (*Baker*).

Male.—Length, 11 millimeters; agrees with the above description of *Parevaspis bakeri* except as follows: Punctures not so coarse, scutel at apex in the middle deeply impressed, almost emarginate, sixth and seventh sternites in outline as figured, fifth sternite simple, without a median or other tooth, hypopygium as figured. Two specimens, the paratopotype No. 17234.

Female.—Length, 10 to 12 millimeters; agrees with the male except in the secondary sexual characters. Three specimens. Los Baños, Luzon, No. 17230; Surigao, Mindanao, No. 17231; and one specimen without a number.

ILLUSTRATION

TEXT FIGURE

FIG. 1. *Parevaspis bakeri* sp. nov., male, *a*, hypopygium; *b*, seventh sternite. *Parevaspis impressus* sp. nov., male, *c*, hypopygium; *d*, seventh sternite.

TWO LARVAL PARASITES FROM THE PHILIPPINE PALM CIVET (PARADOXURUS PHILIPPINENSIS)

By MARCOS A. TUBANGUI

Of the University of the Philippines, Los Baños

TWO TEXT FIGURES

A male Philippine palm civet (*Paradoxurus philippinensis* Jourdan, 1837) was caught near the poultry yards of the College of Agriculture, University of the Philippines, Los Baños, on October 5, 1923, and was presented to me for autopsy through the courtesy of Dr. L. B. Uichanco. Mr. Zacarias de Jesus, who conducted the examination, found in the abdominal cavity two larval parasites, one of which has been previously reported in man in the Philippine Islands, while the other appears to be a new cestode larva.

Armillifer moniliformis var. heymonsi Sambon, 1922.

An oval cyst (fig. 1, *a*), measuring about 3 millimeters long by 2 millimeters wide by 1 millimeter thick, was found in the omentum under the greater curvature of the stomach. Through the thin layer of fibrous connective tissue composing the wall of the cyst, there was visible a coiled, segmented worm which, when mechanically stimulated, showed feeble but distinct movements. When removed from the cyst and examined under a binocular microscope, the segmentation of the worm was more apparent, the segments being marked by thirty rings or annulations which occur in series on the surface of the body. The worm measures 8 millimeters in length by 1 millimeter in maximum width. Its elongate body is divisible into two regions: a short, depressed anterior region, which is free from annulations and bears on the ventral surface four small hooks; and a long, cylindrical posterior region which is annulated and tapers posteriorly to a pointed cone. Except for its size, in other characters it bears a very close resemblance to one of the adult tongue worms which Sambon(4) has recently placed in the new genus *Armillifer*, namely, *A. moniliformis*. The worm is, therefore, identified as the larval or, more correctly, the nymphal form of this linguatulid, and is the second one to be recorded in the Philippine Islands. The first was reported in 1907 by Herzog and Hare(2) who found what is very likely the nymph of the same species encysted in the liver of a Filipino. These authors described the parasite under the name *Porocephalus constrictus* which, according to Sambon, is a synonym for the nymphal form of a closely related species, *A. armillatus*. The general impression is, however, that Herzog and Hare probably had to do with the nymph of *A. moniliformis*, because so far as is known *Armillifer armillatus* is restricted to Africa, while the former is Oriental in distribution.

It is important to emphasize the occurrence of this tongue worm in the Philippines because of its transmissibility to man. It is also important, for practical reasons, to know the mode of its transmission which, fortunately, has been successfully determined by those who studied its life history. The source of infestation is the python, in the lungs of which the sexually mature parasites live and lay their eggs. If introduced into a suitable intermediate host, which is usually an animal preyed upon by pythons, the eggs develop into nymphal forms which are able to migrate through the tissues of the body until they become encysted. Based on two specimens which I have dissected, the Philippine reticulated python is frequently parasitized with *Armillifer moniliformis* or with a variety of this species. Taking into consideration that this snake is often seen near houses in some parts of the country, the danger of its transmitting the eggs of the parasite to human beings is unquestionably great.

SPECIFIC DIAGNOSIS

The following description is based on thirteen adult female specimens obtained from two reticulated pythons which were shot near Mount Maquiling at Los Baños. No adult male specimens are at hand to make the description complete, but I believe, from a comparison of my data with those given by Sambon(4) and Heymons(3) on adult females, that my Philippine specimens belong to a variety of *Armillifer moniliformis* which Sambon designates as *A. moniliformis* var. *heymonsi*.

Color, yellowish in the fresh state and ivory white in preserved specimens. Shape elongate, more or less cylindrical, tapering posteriorly and terminating in a pointed cone. Size, from 30 to 70 millimeters in length by 3 to 5 millimeters in maximum width. Body is annulated, being encircled by thick, prominent bands or rings which are placed at intervals and somewhat obliquely, giving it the appearance of a screw nail. The rings or circlets are about 1 millimeter wide and number from 27 to 31. The most anterior rings are so closely placed that it is often difficult to count them. Posteriorly they are very distinct, being separated by transparent spaces which are from 1 to 2 millimeters wide. The last and, sometimes, the second to the last rings are incomplete on the ventral surface.

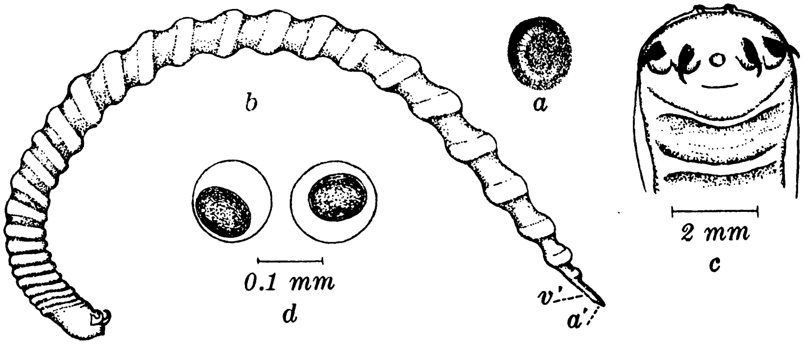

FIG. 1. *Armillifer moniliformis* var. *heymonsi* Sambon; *a*, encysted nymph, × 3.8; *b*, side view of adult female, × 2; *c*, cephalothorax, ventral view, showing the mouth and hooks; *d*, eggs.

The cephalothorax, which measures from 2 to 3 millimeters long by 3.5 to 4 millimeters wide, is not sharply marked off from the abdomen. It is flattened dorsoventrally, the ventral flattening being continued posteriorly as far as the tenth or fourteenth abdominal ring. The circular mouth is located on the ventral surface of the cephalothorax in line with four symmetrically placed hook pits, each of which contains a small, amber yellow hook. The hooks, two on each side of the mouth, are all of the same size and shape, each consisting of a curved, chitinous process about 1 millimeter in length. Two papillæ are present on the anterior border of the cephalothorax, one above and slightly median to each inner hook. An external pair of papillæ in line with the inner pair and above each outer hook is also sometimes seen.

The ringed abdomen contains the straight intestine and the coiled reproductive organs. The anus is located on the ventral surface of the last abdominal segment, about 0.082 millimeter from the tip of the terminal cone. The female genital opening is anterior to and about 1.5 millimeters from the anus. The eggs are oval, double-shelled, and measure from 0.075 to 0.090 millimeter long by 0.056 to 0.064 millimeter wide. They are inclosed in transparent bladders which are from 0.107 to 0.125 millimeter in diameter.

Sparganum philippinensis sp. nov.

A single specimen of what is apparently a new cestode larva was found covered by the peritoneum beneath the psoas muscles. In the fresh state it looks very similar to a shred of fatty tissue or a piece of isolated nerve; it measures about 28 millimeters in length by 1 millimeter in maximum width. When removed from the body of the host and placed in physiological salt solution at room temperature, it exhibited slow, wormlike movements which were continued for nearly half an hour.

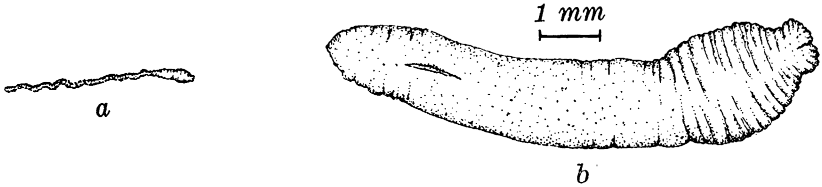

FIG. 2. *Sparganum philippinensis* sp. nov.; *a*, natural size; *b*, head end enlarged, showing invagination and slitlike opening.

The body is flat, nonsegmented, and covered with a cuticle which is very much wrinkled transversely. It is divided by a slight constriction near the junction of its anterior and middle thirds into a wider, shorter, anterior head portion and a narrower, longer, posterior portion. A short distance in front of the constriction there is a longitudinal, slitlike opening, about 1 millimeter in length. Whether or not this opening is an artefact, brought about by mechanical injury during the extraction of the worm from the tissues of the host, cannot be determined. It might possibly be a deep groove which has been ruptured. The anterior border of the head presents a protrusible invagination which is guarded on both sides by papilliform projections. The posterior extremity is rounded and somewhat thinner than the more anterior portions of the body. Neither suckers nor hooks nor other definite structures which would have suggested at once the taxonomic position of this larval parasite were evident during life. Only after it was stained with carmine and mounted, and finding under the microscope that the bulk of the body substance is made up largely of a peculiar parenchymatous tissue in which minute calcareous corpuscles are scattered, was it possible to determine its cestode structure.

Similar forms of larval cestodes have been reported from various hosts, including man, and have been placed provisionally in the pseudogenus *Sparganum* Diesing, 1850, until their true position in the animal kingdom may be better known. It is a common belief, however, that they are the early stages of certain dibothriocephalid or dibothridiate tapeworms, this belief having been apparently confirmed in the case of *Sparganum mansoni* of man which is said to be the plerocercoid of *Dibothriocephalus mansoni* of the dog [Brumpt(1)]. If this view is correct and can be applied in a general sense, the present form, for which I propose the name *Sparganum philippinensis,* must be the larval stage of a cestode belonging to the dibothriocephalid or dibothridiate group. Based on this suspicion and on the observation that it is found in a host harboring another larval parasite, the adult stage of which is spent in the body of a python, I believe it probable that it is the plerocercoid of *Bothridium pithonis,* a very common tapeworm in the intestine of the Philippine *Python reticulatus.*

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. *Armillifer moniliformis* var. *heymonsi* **Sambon; *a,* encysted nymph,** × 3.3; *b,* side view of adult **female,** × **2;** *c,* **cephalothorax,** ventral view, showing the mouth **and hooks;** *d,* **eggs.**

2. *Sparganum philippinensis* sp. nov.; *a,* **natural size;** *b,* **head end** enlarged, showing invagination **and slitlike opening.**

Whereas it has pleased Almighty God in His wise and inscrutable Providence to remove from among us

Dean Conant Worcester

[OCTOBER 1, 1866-MAY 2, 1924]

Whereas at best we can do little at this time to indicate our real appreciation of him as a man and as a worker for the best medical and other scientific interests of the Philippine Islands; and

Whereas it was largely through his efforts, as Secretary of the Interior of the Government of the Philippine Islands, that the Philippine General Hospital, the Bureau of Science, and the College of Medicine were established; Therefore be it

Resolved, That we, members of the Philippine General Hospital, Bureau of Science, and College of Medicine, of Manila, Philippine Islands, do hereby express our deepest sorrow for the death of Dean Conant Worcester; and be it further

Resolved, That he holds a place of highest respect, admiration, and appreciation in the hearts of all of us because of the great good that he did as Secretary of the Interior in organizing the Philippine General Hospital, the Bureau of Science, and the College of Medicine; and be it further

Resolved, That we extend our sincerest sympathy and condolence to his widow, son, daughter, and other relatives; and be it further

Resolved, That these resolutions be engrossed and sent to his widow, and that copies be filed in the archives of the Philippine General Hospital, the Bureau of Science, and the College of Medicine, and published in the newspapers of Manila, in the Philippine Journal of Science, in the Journal of the Philippine Islands Medical Association, and in Science, the official organ of the American Association for the Advancement of Science, of which he was a member.

For the Staff of the Philippine General Hospital:

[L. S.]

FERNANDO CALDERON
JOSE ALBERT
J. I. ABUEL
F. E. JAYME

For the Staff of the Bureau of Science:

[L. S.]

WM. H. BROWN
LEON MA. GUERRERO
R. C. McGREGOR
G. M. DE UBAGO

For the Staff of the College of Medicine:

[L. S.]

FERNANDO CALDERON
LIBORIO GOMEZ
ARTURO GARCIA
D. DE LA PAZ
JOSE ALBERT

At Manila, Philippine Islands, this fifth day of May in the year of our Lord one thousand nine hundred and twenty-four.

ERRATA

VOLUME 23

Page 79, line 12, *for* specimens of these *read* specimens of this.

Page 516, line 3 from bottom, *for* 1,000 milliliters; *read* 100 milliliters;

Page 517, line 17, *for* Table 2.—*Maximum tolerated dose of cresote. read* Table 2.—*Maximum tolerated dose.*

Page 518, line 4, *for* 10 cubic centimeters. *read* 12.5 milliliters.

Page 518, line 8 from bottom, *for* Fig. 1. The maximum tolerated dose of creosote in leprosy patients, *read* Fig. 1. The maximum tolerated dose.

Page 521, line 26, *for* Local Reactions *read* Lepra Reactions.

Page 523, Table 7, column 5, *for* Moderately brief. *read* Moderately long.

Page 524, line 14 from bottom, *for* 81 per cent, *read* 71 per cent.

Page 525, line 4 from bottom, *for* Fig. 2. Progress made by leprosy patients under treatment with creosote, *read* Fig. 2. Progress made by leprosy patients under treatment.

Page 526, line 5, *for* almost *read* approximately.

Page 670, line 44, for *coerulans* read *caerulans.*

Page 671, line 10, for *halconensis* read *confusus.*

Page 671, line 28, for *gloriosus* var. *abbreviatus* read *gloriosus* subsp. *abbreviatus.*

Page 672, line 8, for *coerulans* read *caerulans.*

Page 672, last two lines, *for* Luzon, Benguet, Baguio *read* Luzon, Cagayan, Sanchez Mira.

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Page 265, line 10, *for* $\underline{4.5}$ *read* $\frac{4.5}{2}$.

Page 338, line 38, for *Pachyrrhynchus bakeri* var. read *Pachyrrhynchus pulchellus* var.

Page 468, line 28, for *Zanclodea* read *Zancloidea.*

Page 468, line 36, *for* C2311 *read* 2311.

Page 468, line 38, *for* C2311 *read* 2311.

Page 478, line 11, *for* axial tuffs *read* axial tufts.

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[New generic and specific names and new combinations are printed in clarendon; synonyms and names of species incidentally mentioned in the text are printed in *italic*.]

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